306-F

Geology and Paleontology of Canal Zone and Adjoining Parts of Panama

Description of Tertiary Mollusks (Pelecypods: Propeamussiidae to Cuspidariidae; Additions to Families Covered in P 306-E; Additions to Gastropods; Cephalopods)

GEOLOGICAL SURVEY PROFESSIONAL PAPER 306-F

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Description of Tertiary Mollusks (Pelecypods: Propeamussiidae to Cuspidariidae; Additions to Families Covered in P 306-E; Additions to Gastropods; Cephalopods)

By W. P. WOODRING

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the Panama land bridge

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GEOLOGY AND PALEONTOLOGY OF CANAL ZONE AND ADJOINING PARTS OF PANAMA

DESCRIPTION OF TERTIARY MOLLUSKS (PELECYPODS: PROPEAMUSSIIDAE TO CUSPIDARIIDAE; ADDITIONS TO FAMILIES COVERED IN P 306–E; ADDITIONS TO GASTROPODS; CEPHALOPODS)

By W. P. Woodring

ABSTRACT

The final chapter of Professional Paper 306 consists chiefly of the description of 272 species and subspecies of pelecypods in 41 families. The Veneridae, Tellinidae, Pectinidae, and Cardiidae, in order of decreasing size, are the largest of these families. Two recently acquired, exceptionally large Eocene gastropods from the Gatuncillo formation are also described. Two species of *Aturia*, one from the Bohio formation and the other from the Gatun formation, are the only cephalopods.

The late Eocene fossils from the Gatuncillo formation include a species that is still living: *Lithophaga nigra*. It is the only living species recognized in the Eocene faunas of the Caribbean region. A new cardiid genus, *Chrysocardium*, is based on a silicified valve from the Río Casaya area. The fossils from that area are thought to be of middle Eocene age. *Myrtaea* cf. *M. curta* is the earliest species of the genus so far found in the Caribbean region.

Two new mactrid genera, *Eopapyrina* and *Ovalmactra*, are recognized in the unnamed marine rocks of late Eocene age. *Microcardium microtatum* is by far the earliest and also the smallest species of the genus. In the Caribbean region, *Strigilla protera* is the earliest *Strigilla*, and *Gari listrota* is the earliest species of the subgenus *Gobraeus*.

As in other chapters of this Professional Paper, the only recorded marine mollusks found in the Bohio formation were recovered from thin lenses in the upper part of the formation on Barro Colorado Island. The entire formation is essentially nonmarine. *Anomalocardia heothina* is the earliest known species of the genus. These fossils include two freshwater genera (*Polymesoda* and *Pisidium*).

Flabellipecten gatunensis protistus, the earliest form of that genus in the faunas under study, occurs in the shallow-water facies of the Caimito formation of late Oligocene age, as well as in the Caraba and Panamá formations of the same age, and also in the La Boca formation of early Miocene age.

The fossils from the moderately deepwater facies of the Caimito include a *Propeamussium* that has sculpture similar to that of an Oligocene species from Trinidad.

The Culebra formation yielded the earliest fauna of unmistakable Miocene age. *Tellina ophiaca* and *Psammacoma diphas* are especially characteristic of the transition zone between the Culebra and the overlying Cucaracha formation. The mactrid genus *Trinitasia*, originally based on specimens of uncertain affinities, occurs in the Culebra.

The Cucaracha is nonmarine. In addition to the remains of North American mammals, it has yielded a freshwater unionid(?) and great quantities of coprolites, presumably crocodilian.

The La Boca formation of early Miocene age is the earliest to yield a fauna of considerable size: 80 species and subspecies. Some of these species also occur in the Gatun formation of middle Miocene age; others are predecessors of those in the Gatun. A bed that crops out in the Las Cascadas Reach is characterized by the abundance of a small pectinid (*Lepidopecten proterus*) and a small dimyid (*Dimya adaia*). The oysters include an unnamed species of *Gryphaeostrea*, the first record of a Miocene American species, and a species of *Cubitostrea*: *C. rugifera*. A large edentulous lucinid is described as a species of *Hadralucina*.

The Alhajuela formation of early Miocene age of Madden basin is younger than the formations of early Miocene age in the Gaillard Cut area. The lower member of the Alhajuela contains *Nodipecten clydonus* and *Florimetis trinitaria*. Large specimens of *Flabellipecten gatunensis gatunensis*, *Dinocardium robustum*, and *Dosinia* aff. *D. ponderosa titan* are conspicuous in the upper member of the Alhajuela. The upper member, as well as the Culebra and Gatun formations, contains *Pholadomya*.

Most of the fossils described in the present chapter, 116 species and subspecies, were collected from the richly fossiliferous Gatun formation of middle Miocene age.

Pecten scissuratus is the type of a new genus, *Lepidopecten*. An earlier species of the genus, *L. proterus*, occurs in the Culebra and La Boca formations. *Leptopecten ecnomius* is characteristic of the lower part of the Gatun. The oysters include species of *Pycnodonte*, *Hyotissa*, *Crassostrea*, *Ostrea*, and *Lopha*. *Hyotissa haitensis*, however, is the most widespread species.

The lineage of *Trachycardium dominicense* starts as a small form in the La Boca formation and the lower member of the Alhajuela formation, continues as the typical form in the middle part of the Gatun formation, and culminates as the large *T. dominicense hadratatum* in the upper part of the Gatun in the western area.

The new subgenus *Miratellina* (a subgenus of *Tellina*) is closely related to *Tellina protolyra*, a middle Miocene species from Colombia. *Semele laevis costaricensis*, a predecessor of the living eastern Pacific *S. laevis laevis*, is widespread and locally common in the lower and middle parts of the Gatun.

The venerids of the Gatun are diversified and widespread: 20 species and subspecies. *Agriopoma (Pitarella) gatunensis* ranges throughout the formation. *Clementia dariena dariena* is conspicuous in the lower and middle parts. *Lirophora (Panchione) mactropsis* is the most abundant venerid and was one of the first to be named in 1855. The type is still extant. The species ranges throughout the formation and has been much overnamed. *Bothrocorbula (Hexacorbula) gatunensis* is found throughout the formation, except in the upper part in the western area.

The lineage of *Flabellipecten gatunensis* is continued as *F. gatunensis macdonaldi* in the Toro limestone member of the Chagres sandstone of late Miocene or Pliocene age. *Hyotissa haitensis* also occurs in the Toro.

Flabellipecten gatunensis tapeinus, the end member of the *F. gatunensis* lineage, is found in the Chagres sandstone proper, also of late Miocene or Pliocene age. *Lepidopecten*, a new genus based on *Pecten cactaceus* from Spencer's Coatzacoalcos formation of late Miocene age in the Tehuantepec area of México, occurs in the Chagres sandstone proper.

Of the two species of pelecypods omitted in chapter E, *Nucinella* cf. *N. woodii* is represented in the middle part of the Gatun formation by a minute valve (length 1.1 mm). The other species, *Lithophaga nigra*, is living. It was found in the Gatuncillo formation of Madden basin. It is the only living species recognized in the Eocene faunas of the Caribbean region and in the late Eocene faunas of southern and eastern United States.

A specimen of *Velates perversus*, recently found in the Gatuncillo formation of Madden basin, has a basal diameter of 19 cm. So far as known, this is a size record for America. A large cypraeid, *Megalocypraea* aff. *M. clarki*, also recently found in the Gatuncillo formation of Madden basin, has a length of 16.8 cm.

INTRODUCTION

The sixth, and final, chapter of Professional Paper 306 was started in 1973 and was completed in 1978. It covers 272 described species and subspecies of pelecypods, two of gastropods, and two of cephalopods. These described forms are distributed as follows in the various formations:

Species and subspecies of molllusks described in P 306–F and in entire publication

Formation	*Number of species* P 306–F	P 306–A–E	*Total*
Miocene or Pliocene series:			
Chagres sandstone proper	8	39	47
Toro limestone member	11	2	13
Miocene series:			
Gatun [1]	121	275	396
Alhajuela			
Upper member	13	5	18
Lower member	27	8	35
La Boca proper	66	71	137
Emperador limestone member	17	8	25
Cucaracha	2	1	3
Culebra	18	29	47
Oligocene series:			
Caimito			
Shallow-water facies	7	21	28
Moderately deepwater facies	9	19	28
Quebrancha limestone member	------	2	2
Caraba	2	2	4
Panamá	2	----------	2
Bohio [2]	26	26	52
Eocene series:			
Marine rocks of late Eocene age	20	34	54
Gatuncillo	26	47	73

[1] In Spanish orthography Gatún.
[2] In Spanish orthography Bohío.

As in previous chapters of Professional Paper 306, the faunal tables use the following symbols for relative frequency:

Symbols used for relative frequency

Symbols	*Number of specimens*
R, rare	1–2
F, few	3–5
C, common	6–20
A, abundant	>20

The family order for the pelecypods conforms with that in Part N, Mollusca 6, of the "Treatise on Invertebrate Paleontology," R. C. Moore, editor, except that Chamidae immediately follows Carditidae (see Kennedy, Morris, and Taylor, 1970) and Solecurtidae immediately follows Psammobiidae (see Keen, 1971, p. 244).

ADDITIONS TO ANNOTATED BIBLIOGRAPHY

1973. Bartlett, A. S., and Barghoorn, E. S., Phytogeographic history of the Isthmus of Panama during the last 12,000 years (a history of vegetation, climate, and sea-level changes), *in* Graham, Alan, ed., Vegetation and vegetational history of northern Latin America: New York, Elsevier, p. 203–299, 10 figs.
Based on radiocarbon-dated core samples of informally named Atlantic muck in Gatun Lake area.

1973. Bold, W. A., van den, Ostracoda of the La Boca Formation, Panama Canal Zone: Micropaleontology, v. 18, no. 4 (1972), p. 410–442, 5 pls., 8 figs.

Ostracodes from La Boca, Caimito, and Bohio formations. Includes species from Costa Rica. Sample WF68a is now assigned to Emperador limestone member of La Boca formation, not Caimito formation (see P 306–D, p. 313). The geologic map reproduced by van den Bold has been superseded.

1973 Bold, W. A. van den, La posición estratigráfica de la Formación La Boca, Panamá, Zona del Canal: Inst. Centroamericana Invest. Technologia Inds., Pub. Geol. 4 (Informe y trabajos tecnicos presentados en la Tercera Reunión de Geólogos de América Central, 1971), p. 167–170, 9 figs. [1974].

So far as La Boca, Culebra, and Caimito formations are concerned, this account is a repetition of van den Bold's paper published in 1973. The suggested correlation of the La Boca and Culebra formations is erroneous.

1975. Mock C., Julio, and others, Atlas Nacional de Panamá: [n.p.] Comisión del Atlas de Panamá, 71 pls., and text.

Includes geologic map, pl. 16, scale 1:1,000,000.

1976. Petit, R. E., Notes on Cancellariidae (Mollusca: Gastropoda), III: Tulane Studies Geology and Paleontology, v. 12, no. 1, p. 33–43, 2 pls.

Includes two species from Gatun formation: *Olssonella panamica* and *Trigonostoma (Ventrilia) sacellum*.

1976. Macintyre, I. G., and Glynn, P. W., Evolution of modern Caribbean fringing reef, Galeta Point, Panamá: Am. Assoc. Petroleum Geologists Bull., v. 60, no. 7, p. 1054–1072. 9 figs.

Description of 13 closely spaced, dated core holes, extending from the laboratory of Smithsonian Tropical Research Institute at Galeta Point (7 km northeast of Colón) along two transects across the fringing reef.

The collections of mollusks made by MacDonald and Vaughan, formerly considered of Pleistocene age, but changed to Holocene on p. 325–326 of P 306–D, accumulated in back-reef sediments.

1978. Zachos, L. G., and Shaak, G. D., Stratigraphic significance of the Tertiary echinoid *Eupatagus ingens* Zachos: Jour. Paleontology, v. 52, no. 4, p. 921–1927, 1 pl., 6 figs.

Cook's *Eupatagus clevei*, from the Gatuncillo formation, is identified as illustrated as *E. ingens*, on the basis of specimens from the Ocala limestone of Florida.

1976. Saito, Tsunemasa, Geologic significance of coiling direction in the planktonic Foraminifera *Pulleniatina*: Geology, v. 4, no. 5, p. 305–309, 3 figs.

The end of tropical marine connection across Central America took place about 3.5 m.y. ago.

1978. Keigwin, L. D., Jr., Pliocene closing of the Isthmus of Panama, based on biostratigraphic evidence from nearby Pacific Ocean and Caribbean Sea cores: Geology, v. 6, no. 10, p. 630–634, 3 figs.

A date closer to 3.1 m.y. ago is preferred to Saito's date.

ACKNOWLEDGMENTS

I am especially indebted to Mr. Robert H. Stewart, formerly geologist of the Panama Canal Company, now retired, and his assistant and successor, J. A. Stewart, for the compilation of the 1:100,000 geologic map of the Canal Zone and adjoining parts of the Republic of Panamá, and the 1:25,000 geologic map of the Gaillard Cut area, both reproduced as plate 125 in this report. These two maps take the place of plates 1 and 2 of P306–A, which were known, or suspected, to need improvement. R. J. Risberg, Chief of the Engineering Division, of the Panama Canal Company, approved compilation of these maps and kindly approved their publication in a U.S. Geological Survey Professional Paper.

Thomas R. Waller and Druid Wilson, both of the Department of Paleobiology, of the National Museum of Natural History, served as technical reviewers of the present publication and suggested advice for improvement.

Throughout this long-continued project, May Cronan and Sylvia Pinckney typed manuscript, Barbara Bedette labeled fossils and drew up the distribution tables, Robert McKinney photographed fossils, and Elinor Stromberg made up plates.

NEW GENERIC AND SUBGENERIC NAMES

The following new generic and subgeneric names are proposed:

Chrysocardium, Cardiidae, Fraginae.
Type: *Chrysocardium aurum* Woodring, n. sp., Gatuncillo formation, Eocene, p. 641. Gender neuter.

Eopapyrina, Mactridae, Mactrinae.
Type: *Mactra (Mactrella?) darienensis* Dall, unnamed marine rocks of late Eocene age, p. 648. Gender feminine.

Goniacardia, subgenus of *Trigoniocardia*, Cardiidae, Fraginae.
Type: *Cardium (Fragum) callopleurum* Gabb, Moín formation, Costa Rica, Pliocene, p. 644. Gender feminine.

Lepidopecten, Pectinidae, subfamily(?).
Type: *Pecten (Aequipecten) scissuratus* Dall, Gatun formation, Miocene, p. 592 Gender masculine.

Miratellina subgenus of *Tellina*, Tellinidae, Tellininae.
Type: *Tellina anaxia* Woodring, n. sp., Gatun formation, Miocene, p. 660. Gender feminine.

Ovamactra, Mactridae, Mactrinae.

Type: *Ovamactra cyma* Woodring, n. sp., unnamed marine rocks of late Eocene age, p. 651. Gender feminine.

FAUNAL SUMMARIES AND NOTES ON DEPOSITIONAL ENVIRONMENTS

EOCENE SERIES

GATUNCILLO FORMATION

The distribution of the 26 species described from the Gatuncillo formation is shown in the following table.

Lithophaga nigra is the only living species recognized in the Eocene faunas of the Caribbean region and, according to the catalogs of Palmer and Brann (1965, 1966), also in the late Eocene of southern and eastern United States. *Myrtaea* cf. *M. curta* is the earliest species of the genus in the Tertiary Caribbean province.

Chrysocardium is a new genus based on a silicified valve from the Río Casaya area.

Crenostrea, Cubitostrea, Pseudomiltha, Bathytormus, Chrysocardium, Cytheriopsis, Velates, and *Megalocypraea* are extinct.

Pelecypods (Pectinidae to Veneridae, Mytilidae) and additional gastropods from Gatuncillo formation

[R, rare; F, few; C, common; A, abundant]

	Localities											
	Madden basin							Río Palenque	Río Frijol area		Cerro Pelado	Río Casaya area
	5a	6	9	11	12	12a	16	23b	32	35	37a	38
Lithophaga (Lithophaga) nigra (d'Orbigny)				F								
Propeamussim sp										C		
Spondylus olssoni Clark				R					C			
Anomia cf. *A. lisbonensis* Aldrich								A				
Anomia cf. *A. ephippioides* Gabb									R			
Pycnodonte (Crenostrea) achanes Woodring, n. sp									F			
Crassostrea? sp												F
Cubitostrea? sp				F								
Plastomiltha? *odontota* Woodring, n. sp								F				
Pseudomiltha megameris (Dall)			R	R								
Pseudomiltha? sp					F							
Myrtaea (Myrtaea) cf. *M. curta* (Conrad)								R				
Fimbria jamaicensis (Trechmann)				F								
Fimbria cf. *F. vernoni* Richards			F		R							
Diplodonta? sp								R				
Venericardia (Rotundicardia) sp												R
Venericardia sp [1]			R	C	F		F					
Bathytormus sp											F	
Schedocardia? sp			R	F	C							
Schedocardia? *gatunensis samanica* (Olsson)				C							C	
Trachycardium? sp					C							
Chrysocardium aurum Woodring, n. sp												R
Tellina (Arcopagia) cf. *T. eburneopsis* Conrad			R									
Tellina (Eurytellina?) sp			R									
Tellina sp [1]					R							
Cytheriopsis conradi (Clark)		R										
Pitar (Pitar?) carmenensis Clark				R	F							
Velates perversus (Gmelin) [2]						R						
Megalocypraea aff. *M. clarki* (Ingram)	R											

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[1] Not described.

[2] See P 306–A, p. 66.

As shown in the following table, same species, or related species, occur elsewhere.

Mollusks from Gatuncillo formation and occurrence elsewhere of same or related species

Species from Gatuncillo formation	Occurrence elsewhere of same or related species
Spondylus olssoni Clark	Late Eocene part of Carmen formation, Colombia.
Anomia cf. *A. lisbonensis* Aldrich.	*A. lisbonensis*, middle Eocene, Texas, Alabama, Florida.
Anomia cf. *A. ephippioides* Gabb.	*A. ephippioides*, middle Eocene, Texas.
Pycnodonte (Crenostrea) achanes Woodring, n. sp.	*P. (C.) antiguensis* (Brown), late Oligocene, Antigua.
Pseudomiltha megameris (Dall).	Charco Redondo limestone member of Cobre formation, middle Eocene, Cuba; Avon Park limestone middle Eocene, Florida; Inglis limestone (of former usage), late Eocene, Florida; Versey's Claremont limestone of White Limestone group, middle or late Eocene, Jamaica; Ceru di Cuebra formation, middle or late Eocene, Curaçao.
Myrtaea cf. *M. curta* (Conrad).	*M. curta* (Conrad), late Eocene, Mississippi.
Fimbria jamaicensis (Trechmann).	Yellow Limestone, middle Eocene, Jamaica.
Fimbria cf. *F. vernoni* Richards.	Inglis limestone (of former usage), late Eocene, Florida.
Schedocardia? gatunensis samanica (Olsson).	Samán formation, late Eocene, Perú, late Eocene part of Carmen formation, Bolívar Dept., Colombia.
Cytheriopsis conradi (Clark).	Late Eocene part of Carmen formation, Bolívar Dept., Colombia.
Pitar (Pitar?) carmenensis Clark.	Late Eocene part of Carmen formation, Bolívar Dept., Colombia.

UNNAMED MARINE ROCKS OF LATE EOCENE AGE

The fauna of the map unit, "Marine rocks of late Eocene age," is the most distinctive of the succession of the 18 faunas under study. The 20 species covered in the present chapter are listed in the following table.

The fossils from this unnamed unit include two new mactrid genera, *Eopapyrina*, doubtless a predecessor of *Papyrina*, and *Ovamactra*, also the earliest known species of *Strigilla* (*S. protera*), and the earliest species of the subgenus *Gobraeus* [*Gari (Gobraeus) listrota listrota*]. *Microcardium microtatum* is by far the earliest and also the smallest species of the genus. On account of Dall's erroneous designation of the type locality of *Lamelliconcha hillii*, that species has been considered a species of the Gatun formation. *Eopapyrina* and *Ovamactra* are extinct.

Pelecypods (Carditidae to Corbulidae) from marine rocks of late Eocene age

[R, rare; F, few; C, common; A, abundant]

	Localities									
	Vamos Vamos					Palenquilla Point			Trinidad Island	
	40	40a	40b	40d	40e	41	41a	41b	42	42a
Venericardia (Rotundicardia?) sp	----	----	----	----	----	C	----	----	--------	--------
Lucinisca protista Woodring, n. sp	----	----	----	----	----	----	----	----	R	--------
Schedocardia? gatunensis gatunensis (Dall)	----	C	R	C	----	C	----	F	--------	--------
Microcardium microtatum Woodring, n. sp	----	----	----	C	----	----	----	A	--------	--------
Eopapyrina darienensis (Dall)	R	C	----	A	R	A	F	A	F	--------
Genus? cf. *Mulinia*	----	R	----	R	----	----	----	----	R	--------
Ovamactra cyma Woodring, n. sp	----	F	----	----	----	R	C	R	--------	--------
Ervilia sp	----	----	----	----	----	----	----	R	--------	--------
Tellina (Arcopagia?) acares Woodring, n. sp	----	----	----	C	R	----	----	A	--------	--------
Tellina (Eurytellina) alincia Woodring, n. sp	----	R	----	R	R	----	----	----	R	--------
Tellina (Angulus?) sp	----	----	----	F	----	----	----	----	--------	--------
Strigilla (Strigilla) protera Woodring, n. sp	----	R	----	A	C	F	R	C	--------	--------
Gari (Gobraeus) listrota listrota Woodring, n. sp. and subsp	----	F	----	C	----	A	R	F	--------	--------
Semele sp	----	----	----	----	----	----	----	R	--------	--------
Pitar (Pitar?) yasila (Olsson)	----	R	----	----	----	----	----	----	--------	--------
Lamelliconcha hillii (Dall)	----	R	----	A	----	?R	----	R	F	R
Costacallista gabrielensis (Clark)	----	R	----	R	----	C	R	C	R	R
Parastarte(?) sp	----	----	----	----	A	A	----	----	--------	--------
Caryocorbula phruda Woodring, n. sp	R	F	----	F	R	C	----	C	--------	--------
Caryocorbula sp [1]	----	----	----	----	R	----	----	----	C	--------
Varicorbula baea Woodring, n. sp	----	----	----	----	----	----	----	----	C	--------

[1] Not described.

The occurrence elsewhere of the same or related species is shown in the following table:

Mollusks from marine rocks of late Eocene age and occurrence elsewhere and in other Canal Zone formations of same or related species

Species from marine rocks of late Eocene age	Occurrence elsewhere of same or related species
Schedocardia? gatunensis gatunensis (Dall).	*S.? gatunensis samanica* (Olsson), Gatuncillo formation, late Eocene; Samán formation, late Eocene, Perú; late Eocene part of Carmen formation, Colombia.
Tellina (Eurytellina) alincia Woodring, n. sp.	*T. (E.) punicea* Born, late Oligocene to Holocene.
Gari (Gobraeus) listrota listrota Woodring, n. sp. and subsp.	*G. (G.) jackonensis* Richards, Inglis limestone (of former usage), late Eocene, Florida.
Pitar (Pitar?) yasila (Olsson).	Talara formation, late Eocene, Perú.
Lamelliconcha hillii (Dall)	Samán formation, late Eocene, Perú.
Costacallista gabrielensis (Clark).	Late Eocene part of Carmen formation, Colombia.

OLIGOCENE SERIES

BOHIO FORMATION

Lenses in the upper part of the essentially nonmarine Bohio formation on Barro Colorado Island yielded 26 species covered in the present chapter. They are listed in the following table. For the most part, these fossils are marine. They include, however, brackish-water species and even freshwater species.

The earliest record for *Raeta* is in this unit and in the moderately deep water facies of the Caimito formation. *Tellina (Tellinella) protera* is the earliest *Tellinella* in the Caribbean region. Likewise, *Tagelus* of the subgenus *Tagelus* s.s. is the earliest in the Tertiary Caribbean province, and *Anomalocardia heothina* and *Pleiorytis orthra* are the earliest species of those genera. A small form of *Macrocallista maculata*, found also in the shallow-water facies of the Caimito formation, extends the range of that species back to late Oligocene. *Aturia* is extinct.

Pelecypods (Pectinidae to Thraciidae) and cephalopod (Nautilidae) from upper part of Bohio formation on Barro Colorado Island

[R, rare; F, few; C, common; A, abundant]

	Localities				
	42d	42e	42f	42g	42i
Flabellipecten antiguensis (Brown)	F	---	---	---	---
Anomia cf. *A. peruviana gabbi* Pilsbry and Johnson	R	---	---	---	---
Crassostrea cahobasensis (Pilsbry and Brown)	---	R	R	---	---
Lucinisca protista Woodring, n. sp	R	---	---	---	---
Miltha sp	R	---	R	---	---
Divaricella sp [1]	---	---	---	R	---
Diplodonta (Diplodonta) cf. *D. alta* Dall	C	---	A	R	---
Trachycardium (Dallocardia) phlyctaena (Dall)?	---	---	---	---	R
Trachycardium (Dallocardia) cf. *T. (D.) dominicense* (Gabb)	A	---	---	F	---
Raeta cf. *R. gardnerae* (Spieker)	---	---	---	---	F
Tellina (Tellinella) protera Woodring, n. sp	F	---	---	---	---
Tellina (Merisca?) pyena Woodring, n. sp	---	---	R	---	---
Tellina sp	R	---	---	R	R
Gari (Gobraeus) listrota hadratera Woodring, n. subsp	C	---	C	---	---
Solecurtus vicksburgensis Aldrich	R	---	---	---	---
Tagelus (Tagelus) orthrius Woodring, n. sp	---	---	C	---	R
Semele cf. *S. venusta* (Reeve)	R	---	---	---	---
Polymesoda cf. *P. aequilatera* (Deshayes)	---	---	R	---	---
Pisidium atopum Woodring, n. sp	---	---	R	R	---
Macrocallista (Paradione) maculata (Linné), small form	R	---	---	---	---
Dosinia (Dosinia) aff. *D. delicatissima* Brown and Pilsbry	C	---	---	---	---
Chione (Chionopsis) cf. *C. (C.) posorjensis* Olsson	C	---	R	C	F
Anomalocardia heothina Woodring, n. sp	---	---	A	---	C
Pleiorytis orthra Woodring, n. sp	R	---	---	---	---
Caryocorbula platys Woodring, n. sp	F	---	R	R	---
Cyathodonta? dolicha Woodring, n. sp	R	---	---	---	---
Aturia sp	R	---	---	---	---

[1] Not described.

The occurrence elsewhere of the same or related species is shown in the following table:

Mollusks from Bohio formation and occurrence elsewhere and in other Canal Zone formations of the same or related species

Species from Bohio formation	Occurrence elsewhere and in other Canal Zone formations of same or related species
Flabellipecten antiguensis (Brown).	Shallow-water facies of Caimito formation, late Oligocene; Antigua formation, late Oligocene, Antigua; Lares limestone, late Oligocene, Puerto Rico; La Boca formation and its Emperador limestone member, Gaillard Cut area, early Miocene.
Crassostrea cahobasensis (Pilsbry and Brown).	Culebra and La Boca formations, early Miocene; lower member of Alhajuela formation, early Miocene; Gatun formation, middle Miocene. Late Oligocene to middle(?) Miocene elsewhere.
Diplodonta (Diplodonta) cf. *D. alta* Dall.	*D. (D.) alta* Dall, Chipola formation, early Miocene, Florida; shallow-water facies of Caimito formation, late Oligocene.

Mollusks from Bohio formation and occurrence elsewhere and in other Canal Zone formations of the same or related species—Continued

Species from Bohio formation	Occurrence elsewhere and in other Canal Zone formations of same or related species
Trachycardium (*Dallocardia*) *phlyctaena* (Dall)?	*T.* (*D.*) *phylctaena* Dall, Tampa limestone, early Miocene, Florida.
Trachycardium (*Dallocardia*) cf. *T.* (*D.*) *dominicense* (Gabb).	*T.* (*D.*) *dominicense* (Gabb), Miocene, Dominican Republic.
Raeta cf. *R. gardnerae* (Spieker).	*R. gardnerae* (Spieker), upper part of Zorritos formation, middle Miocene, Perú. Moderately deep water facies of Caimito formation, late Oligocene.
Tellina (*Tellinella*) *protera* Woodring, n. sp.	*T.* (*T.*) *listeri* Roding, Holocene, Caribbean Sea.
Gari (*Gobraeus*) *listrota hadratera* Woodring, n. subsp.	*G.* (*G.*) *listrota listrota* Woodring, n. sp. and subsp., marine rocks of late Eocene age.
Solecurtus vicksburgensis Aldrich.	Mint Spring marl member of Marianna limestone or Byram formation, Mississippi, middle Oligocene.
Tagelus (*Tagelus*) *orthrius* Woodring, n. sp.	*T.* (*T.*) *gibbus* (Spengler), late Miocene to Holocene, western Atlantic Ocean.
Semele cf. *S. venusta* (Reeve).	*S. venusta* (Reeve). Holocene, eastern Pacific Ocean.
Polymesoda cf. *P. aequilatera* (Deshayes).	*P. aequilatera* (Deshaves). Holocene, northern South America.
Pisidium atopum Woodring, n. sp.	*P. forbesii* Philippi, Holocene, western South America.
Macrocallista (*Paradione*) *maculata* (Linné), small form.	Shallow-water facies of Caimito formation, late Oligocene.
Dosinia aff. *D.* (*D.*) *delicatissima* Brown and Pilsbry.	*D.* (*D.*) *delicatissima* Brown and Pilsbry. La Boca formation, early Miocene; upper member of Alhajuela formation, early Miocene; Gatun formation, middle Miocene.
Chione (*Chionopsis*) cf. *C.* (*C.*) *posorjensis* (Olsson).	*C.* (*C.*) *posorjensis* (Olsson), late Oligocene, Perú, Ecuador.
Anomalocardia heothina Woodring, n. sp.	*A. flexuosa* (Linné), Pliocene to Holocene, western Atlantic Ocean.
Pleiorytis orthra Woodring, n. sp.	*P. caroniana* (Maury), late Miocene, Trinidad.

MARINE FACIES

The marine facies of the Bohio formation is recognized at the base of the Bohio Peninsula and along the northern part of the pipeline road extending northwestward from Gamboa.

Cuts along the east side of the Panama Railroad and exposures on nearby small streams show moderately coarse conglomerate containing small clasts of basalt, and sandstone containing a few unidentifiable gastropods and small benthonic Foraminifera.

On the steep slope on the west side of the ridge at the end of the pipeline road, near fossil locality 29, sandstone contains a small *Lepidocyclina*, suggestive of *L. canellei*, and small benthonic Foraminifera.

CAIMITO FORMATION

SHALLOW-WATER FACIES

The seven species from the shallow-water facies of the Caimito formation described in the present chapter are listed in the following table.

Flabellipecten gatunensis protistus, the earliest member of the *F. gatunensis* group, occurs in this unit, as well as in the Caraba, Panamá, and La Boca formations. *F. antiguensis* also is represented, and *Nodipecten denaius* is doubtfully present. The small form of *Macrocallista maculata* is shared with the Bohio formation, and the earliest record of *Kuphus "incrassatus"* in the faunas under study is in the shallow-water facies of the Caimito.

Pelecypods (Pectinidae to Teredinidae) from shallow-water facies of Caimito formation in Gatun Lake area

[R, rare; C, common]

	Localities					
	52	52a	55b	56	57	57a
Flabellipecten gatunensis protistus Woodring, n. subsp	---	---	---	C	---	?sp.R
Flabellipecten antiguensis (Brown)	---	---	---	R	R	------
Aequipecten sp	R	R	---	---	---	------
Nodipecten denaius Woodring, n. sp.?	---	R	---	---	---	------
Anomia sp	---	---	R	---	---	------
Phacoides sp [1]	---	---	R	---	---	------
Pegophysema cf. *P. mauryae* (Pilsbry and Johnson)	---	---	---	C	---	------
Diplodonta (*D.*) cf. *D. alta* Dall	---	---	---	---	---	R
Ventricolaria sp	---	---	R	---	---	------
Macrocallista (*Paradione*) *maculata* (Linné), small form [1]	---	---	---	---	R	------
Chione sp [1]	---	---	---	---	---	R
Kuphus "incrassatus Gabb"	---	---	---	C	---	R

[1] Not described.

MODERATELY DEEP WATER FACIES

The moderately deep water facies of the Caimito formation is represented on Barro Colorado Island and on Pato Horqueto Island. The nine species from this unit described in the present chapter are listed in the following table.

The fossils include *Propeamussium* cf. *P. pennyi*, allied to a species from Trinidad, and *Phacoides cerma*, the earliest and smallest species of the genus in the Caribbean region. *Myrtaea* (*M.*) *enischna* and *Microcardium pollostum* are represented and a species still living, *Tellina* (*Eurytellina*) *punicea*. *Raeta* cf. *R. gardnerae*, which occurs also in the Bohio formation, is allied to a middle Miocene species from Perú.

Pelecypods (Propeamussiidae to Cuspidariidae) from moderately deep water facies of Caimito formation in Gatun Lake area

[R, rare; F, few; C, common]

	Localities							
	54g	54h	54j	54k	54l	54m	54n	55a
Propeamussium cf. *P. pennyi* (Harris)	---	---	---	---	---	---	---	R
Phacoides cerma Woodring, n. sp	---	C	---	R	---	R	---	---
Myrtaea (*Myrtaea*) *enischna* Woodring, n. sp	---	C	F	C	---	---	---	---
Unidentified lucinid?[1]	R	---	---	---	---	---	---	---
Microcardium pollostum Woodring, n. sp	---	---	R	F	---	---	---	---
Raeta cf. *R. gardnerae* (Spieker)	---	---	---	---	R	---	---	---
Tellina (*Eurytellina*) *punicea* Born	---	R	---	R	---	F	---	---
Tellina sp[1]	---	---	---	---	---	R	---	---
Cyclinella? sp[1]	---	---	---	---	R	---	---	---
Chione sp[1]	---	---	---	---	---	---	R	---
Cardiomya sp	---	---	---	---	---	R	---	---

[1] Not described.

The occurrence of the same species, or related species, elsewhere, and in other Canal Zone formations, for both facies, is shown in the following table:

Mollusks from Caimito Formation and occurrence elsewhere and in other Canal Zone formations of the same or related species

Species from Caimito formation	Occurrence elsewhere and in other Canal Zone formations of same or related species
Shallow-water facies:	
Flabellipecten gatunensis protistus Woodring, n. subsp.	Caraba and Panamá formations, late Oligocene; La Boca formation, early Miocene.
Flabellipecten antiguensis (Brown).	Bohio formation, late Oligocene; Antigua formation, late Oligocene, Antigua; Lares limestone, late Oligocene, Puerto Rico; La Boca formation and its Emperador limestone member. Gaillard Cut area, early Miocene.
Nodipecten denaius Woodring? n. sp.	*Nodipecten denaius*, La Boca formation, Gaillard Cut area, early Miocene; Emperador limestone member of La Boca formation, Madden basin, identification doubtful.
Pegophysema cf. *P. mauryae* (Pilsbry and Johnson).	*P. mauryae* (Pilsbry and Johnson), Miocene, Dominican Republic.
Diplodonta (*D.*) cf. *D. alta* Dall.	*D.* (*D.*) *alta* Dall, Chipola formation, early Miocene, Florida; Bohio formation, late Oligocene.
Macrocallista (*Paradione*) *maculata* (Linné), small form.	Bohio formation, late Oligocene.
Kuphus "*incrassatus* Gabb"	Culebra formation, early Miocene; La Boca formation and its Emperador limestone member, early Miocene; Gatun formation, middle Miocene: late Oligocene to middle Miocene elsewhere.
Moderately deep water facies:	
Propeamussium cf. *P. pennyi* (Harris).	*P. pennyi* (Harris), Oligocene part Cipero formation, Trinidad.
Myrtaea (*M.*) *enischna* Woodring, n. sp.	*M.* (*M.*) *vicksburgensis* (Casey), Oligocene, Mississippi.
Raeta cf. *R gardnerae* (Spieker).	*R. gardnerae* (Spieker), upper part of Zorritos formation; Perú. Bohio formation, late Oligocene.
Tellina (*Eurytellina*) *punicea* Born.	Late Oligocene to Holocene, Caribbean region.

CARABA AND PANAMA FORMATIONS

Both the Caraba and Panamá formations consist chiefly of agglomerate. *Flabellipecten gatunensis protistus* was found in both formations, as well as in the shallow-water facies of the Caimito formation and in the younger La Boca formation.

The occurrence in both formations of species described in the present chapter is as follows:

Occurrence in Caraba and Panamá formations of species described in present chapter

	Localities	
Species	*Caraba formation*	*Panamá formation*
Flabellipecten gatunensis protistus Woodring, n. subsp	60	44
Argopecten? sp	60	--
Nodipecten sp	--	45

At locality 39, on the south limb of the Quebrancha syncline, sandy siltstone in graywacke grit at the base of the Panamá formation yielded early Oligocene benthonic Foraminifera (P 306–A, p. 26–27). The age of the Panamá is early to late Oligocene.

MIOCENE SERIES

CULEBRA FORMATION

The 18 species from the Culebra formation described in the present chapter are listed in the following table.

Though the fauna of the Culebra is not extensive, it has an unmistakable Miocene cast. *Crassostrea cahobasensis* is widespread and locally abundant. *Lucina* (*Epilucina*) aff. *L.* (*E.*) *gratis* is closely related to *L.* (*E.*) *gratis*, which occurs in the Gatun formation. *Trinitasia* aff. *T. sanctiandreae* is a representative of a genus originally named without any knowledge of its affinities, but it is now known to be a mactrid (Woodring, 1974, p. 212). It is an extinct genus. *Tellina* (*Eurytellina*) *ophiaca* and *Psammacoma diphas* are especially characteristic of the transition zone between the Culebra and Cucaracha formations, which is grouped with the Culebra (P. 306–A, p. 35). *Pitar* (*Hyphantosoma*) aff. *P.* (*H.*) *centangulatus* is regarded as a small predecessor of *P.* (*H.*) *centangulatus*, of the Gatun formation, and *Clementia* (*C.*) *dariena rabelli* appears to be a small predecessor of *C.* (*C.*) *dariena dariena*, also of the Gatun formation. *Bothrocorbula* (*Hexacorbula*) *cruziana* is the earliest known *Hexacorbula*. *Pholadomya* occurs in the Culebra as well as in the upper member of the Alhajuela and in the Gatun.

Pelecypods (Pectinidae to Pholadomyidae) from Culebra formation

[R, rare; F, few; C, common; A, Abundant]

	Localities																		
	103	104	104a	104b	105	106	107	107a	108a	108c	110	110a	111	111a	111b	112	112a	112b	112c
Lepidopecten proferus Woodring, n. sp.?	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	R	----	----
Crassostrea cahobasensis (Pilsbry and Brown)	A	F	C	C	R	F	----	----	----	----	F	----	----	----	----	----	----	----	----
Phacoides cf. *P. pectinata domingensis* Dall	----	----	----	----	----	----	R	----	----	F	C	----	----	----	----	----	----	----	----
Lucina (*Lepilucina*) aff. *L. gratis* Olsson	----	----	----	----	----	R	----	----	----	----	----	----	R	----	----	----	----	----	----
Lucinoma sp. a[1]	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	R	----
Carditamera cf. *C. vaughani* (Dall)	----	----	----	----	----	----	----	R	----	----	----	----	----	----	----	----	----	----	----
Venericardia sp[1]	----	----	----	----	----	R	----	R	----	----	R	----	----	----	R	F	R	----	----
Trachycardium (*Dallocardia*) *phlyctaena* (Dall)	----	----	----	----	----	F	----	----	----	----	----	----	----	----	C	----	----	----	----
Trinitasia aff. *T. sanctiandreae* (Maury)	----	----	----	----	----	----	----	----	----	F	----	----	----	----	----	----	----	----	----
Tellina (*Eurytellina*) *ophiaca* Woodring, n. sp	----	----	----	----	----	----	----	----	----	----	A	----	----	A	R	F	A	----	----
Psammacoma diphas Woodring, n. sp	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	A	----	----
Donax sp[1]	----	----	----	----	----	----	----	----	----	R	----	----	----	----	----	----	----	----	----
Solecurtus sp[1]	----	----	----	----	----	----	----	----	----	----	----	----	----	----	R	----	----	----	----
Tivela (*Tivela*) *mactroides* (Born), small form	----	----	----	----	----	----	----	----	----	----	----	----	----	R	----	----	----	----	----
Pitar (*Pitar*) aff. *P. quirosanus* (H. K. Hodson)	----	----	----	----	----	----	----	----	----	----	----	R	----	----	----	R	R	----	----
Pitar (*Hyphantosoma*) aff. *P.* (*H.*) *centangulatus* Brown and Pilsbry	----	----	----	----	----	----	----	----	----	----	----	----	----	----	R	----	----	----	----
Macrocallista (*Paradione*) *maculata* (Linné)	----	----	----	----	----	F	----	----	----	----	----	----	----	----	R	R	----	----	----
Dosinia sp[1]	----	----	----	----	----	R	----	----	----	----	----	----	R	----	----	----	----	----	----
Cyclinella? sp[1]	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	R	----	----
Clementia (*Clementia*) *dariena rabelli* Maury	----	----	----	----	----	----	----	R	R	----	F	----	----	R	C	R	----	----	----
Lirophora (*Lirophora*) cf. *L. quirosensis* (H. K. Hodson)	----	----	----	----	----	R	----	----	----	----	----	----	----	----	----	----	----	----	----
Lirophora (*Panchione*?) sp. b[1]	----	----	----	----	----	----	----	R	----	----	R	----	----	----	----	R	----	----	----
Bothrocorbula (*Hexacorbula*) *cruziana* (Olsson)	----	----	----	----	----	----	----	C	----	----	R	F	----	R	C	A	C	----	----
Unidentifiable tubes of wood-boring teredinids	----	----	----	----	C	C	----	----	----	----	C	----	----	----	----	----	----	----	----
Kuphus "*incrassatus* Gabb"	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	R	F	R
Pholadomya cf. *P. walli* Maury	----	----	----	----	----	----	----	----	----	----	----	----	R	----	----	----	----	----	----

---

[1] Not described.

The same or related species that occur elsewhere and in other Canal Zone formations are given in the following table:

Mollusks from Culebra formation and occurrence elsewhere and in other Canal Zone formations of the same or related species

Species from Culebra formation	Occurrence elsewhere and in other Canal Zone formations of same or related species
Lepidopecten proterus Woodring, n. sp.?	La Boca formation, early Miocene, Gaillard Cut and Las Cruces areas.
Crassostrea cahobasensis (Pilsbry and Brown).	Bohio formation, late Oligocene; La Boca formation, early Miocene; lower member of Alhajuela formation, early Miocene; Gatun formation, middle Miocene. Late Oligocene to middle Miocene elsewhere.
Phacoides cf. *P. pectinata domingensis* Dall.	La Boca formation, Gaillard Cut area, early Miocene.
Lucina (*Lepilucina*) aff. *L.* (*L.*) *gratis* Olsson.	*L.* (*L.*) *gratis* Olsson, Gatun formation, middle Miocene; Angostura formation, middle Miocene, Ecuador.
Carditamera cf. *C. vaughani* (Dall).	*C. vaughani* (Dall), late Miocene, Florida.
Trachycardium (*Dallocardia*) *phlyctaena* (Dall).	Bohio formation, late Oligocene, identification doubtful; La Boca formation, Gaillard Cut area, early Miocene; lower member of Alhajuela formation early Miocene; Tampa limestone, early Miocene Florida.
Trinitasia aff. *T. sanctiandreae* (Maury).	*T. sanctiandreae* (Maury), San Jose calcareous silt member of Manzanilla formation, late middle Miocene, Trinidad.

Mollusks from Culebra formation and occurrence elsewhere and in other Canal Zone formations of the same or related species—Continued

Species from Culebra formation	Occurrence elsewhere and in other Canal Zone formations of same or related species
Tellina (*Eurytellina*) *ophiaca* Woodring, n. sp.	*T.* (*E.*) *tumbezensis* Olsson, Holocene, eastern Pacific Ocean; La Boca formation, early Miocene.
Psammacoma diphas Woodring, n. sp.	*P. gatunensis* (Toula), Gatun formation, middle Miocene; La Boca formation, early Miocene.
Tivela (*Tivela*) *mactroides* (Born), small form.	*T.* (*T.*) *mactroides* (Born), middle Miocene to Holocene, Caribbean region; La Boca formation, early Miocene; lower member of Alhajuela formation, early Miocene; Gatun formation, middle Miocene.
Pitar (*P.*) aff. *P.* (*P.*) *quirosanus* (H. K. Hodson).	*P.* (*P.*) *quirosanus* (H. K. Hodson), early Miocene, Bolívar, Venezuela; La Boca formation, early Miocene.
Pitar (*Hyphantosoma*) aff. *P.* (*H.*) *centangulatus* Brown and Pilsbry.	*P.* (*H.*) *centangulatus* Brown and Pilsbry, Gatun formation, middle Miocene.
Macrocallista (*Paradione*) *maculata* (Linné).	Early Miocene to Holocene, Caribbean region.
Clementia (*C.*) *dariena rabelli* Maury.	San Sebastián formation and Lares limestone, late Oligocene, Puerto Rico; Hershey's (1901) Santiago formation, Santiago area, Panamá, late Oligocene; Pirabas formation, early Miocene, Brasil. Deposits of early Miocene age, Chiriquí Province, Panamá; San Jose calcareous silt member of Manzanilla formation, middle Miocene, Trinidad.
Lirophora (*L.*) cf. *L.* (*L.*) *quirosensis* (H. K. Hodson).	*L.* (*L.*) *quirosensis* (H. K. Hodson), early Miocene, Zulia, Venezuela; La Boca formation, early Miocene, Gaillard Cut area.
Bothrocorbula (*Hexacorbula*) *cruziana* (Olsson).	Lower part of Zorritos formation, early Miocene, Perú; La Boca formation, early Miocene.
Kuphus "*incrassatus* Gabb"	Shallow-water facies of Caimito formation, late Oligocene; La Boca formation and its Emperador limestone member, early Miocene; Gatun formation, middle Miocene; late Oligocene to middle Miocene elsewhere.
Pholadomya cf. *P. walli* Maury.	*P. walli* Maury, middle Miocene, Trinidad.

CUCARACHA FORMATION

Aside from molds of *Anadara*, a lucinid?, and *Tellina* (*Eurytellina*) *ophiaca*? in black carbonaceous shale at the base of the Cucaracha, the mollusks of that formation are nonmarine. *Hemisinus* (*Longiverena*) aff. *H.* (*L.*) *oeciscus* has been recorded in

P 306–B (p. 157). In the present chapter, the gaping internal mold of a fresh-water mussel, identified as an undetermined genus of unionid? is recorded. This fossil was found loose on the slope of the lower part of the formation, the part that contains great quantities of coprolites, presumably crocodilian.

Through the kindness of Professor Fred W. McDowell, of the University of Texas at Austin, two potassium-argon dates are available on the thin dacitic ash-flow tuff in the lower part of the formation: 22.2±1.7 and 18.9±2.2 m.y. before present. The concentration of potassium is low in both samples.

LA BOCA FORMATION

The fauna of the La Boca formation is the earliest of considerable size. The 66 species covered in the present chapter are listed in the following table. They bring the total for the formation, exclusive of the Emperador limestone member, to 130 species. In P 306–A and B, the Culebra and La Boca formations were confused.

This is the last appearance of *Flabellipecten gatunensis protistus* and of *F. antiguensis*. Both *Amusium sol* and *A. toulae* occur in the La Boca. *Aequipecten canalis* is especially characteristic of the formation. Other pectinids include *Lepidopecten proterus* and *Nodipecten denaius*. *Dimya adaia* is very abundant in a bed in the Las Cascadas Reach. "*Hyotissa*" *tryoni* is endemic in the faunas under study, and *Hyotissa haitensis* makes its earliest appearance in the La Boca. *Gryphaeostrea* is unusual in an American formation of Miocene age. *Crassostrea cahobasensis* and *Cubitostrea rugifera* are other ostreids in the La Boca.

A large edentulous lucinid is described as *Hadralucina xenica*. *Venericardia* (*Glyptoactis*) *metaicha* and *Chama strepta* are conspicuous species. *Nemocardium hadraterum* and a species from the Tampa limestone of Florida are the last known American representatives of an essentially Cretaceous and early Tertiary genus that survives in Japanese waters.

Two specimens from the La Boca are identified as *Clementia* (*C.*) *dariena dariena*. They are intermediate in size between *C.* (*C.*) *dariena rabelli* and *C.* (*C.*) *dariena dariena*. Other specimens from the La Boca are small and are listed as *C.* (*C.*) *dariena* subsp.?. *Bothrocorbula* (*Hexacorbula*) *cruziana* occurs in the La Boca as well as in the Culebra. *Gryphaeostrea* and *Hadralucina* are extinct.

Pelecypods (Propeamussiidae to Cuspidariidae)

[R, rare; F, few;

	Localities																	
	Gaillard Cut area																	
	99	99a	99b	99c	99d	99e	99f	99g	99h	100	100a	100b	101	101a	101b	101c	101d	101e
Cyclopecten sp. a	----	----	----	----	----	----	----	R	----	----	----	----	----	----	----	----	----	----
Cyclopecten sp. b	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Cyclopecten oligolepis (Brown and Pilsbry)?	----	----	----	----	----	R	----	----	----	----	----	----	----	----	----	----	----	----
Flabellipecten gatunensis protistus Woodring, n. subsp	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Flabellipecten antiguensis (Brown)	----	----	----	----	----	----	A	----	----	----	----	----	----	----	----	----	----	----
Amusium sol (Brown and Pilsbry)	----	----	----	----	----	----	R	F	----	----	----	----	----	----	----	----	----	----
Amusium toulae (Brown and Pilsbry)	----	----	----	----	A	F	----	----	R	----	----	----	----	----	----	----	----	----
Chlamys anguillensis (Guppy)	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Aequipecten canalis (Brown and Pilsbry)	----	F	----	C	A	----	F	A	A	----	----	----	----	----	----	----	----	F
Aequipecten sp[1]	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Lepidopecten proterus Woodring, n. sp	----	----	A	F	----	----	R	F	----	----	----	----	----	----	----	----	----	----
Leptopecten sp[1]	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Nodipecten denaius Woodring, n. sp	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Spondylus scotti Brown and Pilsbry	R	R	----	----	----	----	R	R	R	----	----	R	----	----	R	----	----	F
Dimya adaia Woodring, n. sp	----	----	----	----	----	----	A	----	----	----	----	----	----	----	----	----	----	----
Limaria? sp	----	----	----	R	R	----	----	----	----	----	----	----	----	----	----	----	----	----
Anomia sp	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
"*Hyotissa*" *tryoni* (Gabb)	----	----	----	----	----	----	----	----	----	----	----	----	----	----	R	----	----	----
Hyotissa haitensis (Sowerby)	----	----	----	----	?F	----	R	R	----	----	----	----	----	?R	----	----	----	----
Gryphaeostrea sp	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Crassostrea cahobasensis (Pilsbry and Brown)	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Cubitostrea rugifera (Dall)	----	----	----	----	----	----	----	----	----	----	----	----	----	R	F	R	----	----
Phacoides cf. *P. pectinata domingensis* Dall	----	----	----	----	----	----	----	----	----	----	----	----	R	----	----	----	----	----
Lucinisca cf. *L. calhounensis* (Dall)	----	----	R	----	----	----	----	----	----	----	R	----	----	----	----	----	----	----
Parvilucina cf. *P. yaquensis* (Gabb)	----	----	----	R	----	----	----	----	----	----	C	----	----	----	----	----	R	----
Codakia (*Codakia*) sp	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Myrtaea? (*Myrtaea*?) sp[1]	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Pegophysema cf. *P. mauryae* (Pilsbry and Johnson)	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	R
Hadralucina xenica Woodring, n. sp	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Divaricella sp[1]	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Unidentified lucinid[1]	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Carditamera cf. *C. tegea* (Dall)	----	----	F	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Carditamera sp[1]	----	----	----	----	----	----	----	----	----	----	----	----	----	----	R	----	----	----
Venericardia (*Glyptoactis*) *metaicha* Woodring, n. sp	----	----	----	----	R	----	F	F	----	----	----	----	----	----	----	----	----	----
Chama strepta Woodring, n. sp	----	----	----	----	----	----	R	R	R	----	----	----	----	----	----	----	----	----
Arcinella sp	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Eucrassatella (*Eucrassatella*) *mediamericana* (Brown and Pilsbry)	----	----	----	----	----	----	R	----	----	----	----	----	----	----	----	----	----	----
Trachycardium (*Trachycardium*) cf. *T. isocardia* (Linné)	----	----	----	----	----	----	A	R	----	----	----	----	----	----	----	----	----	----
Trachycardium (*Dallocardia*) *phlyctaena* (Dall)	----	----	----	F	F	----	----	----	R	----	----	----	----	----	----	----	----	----
Trachycardium (*Dallocardia*) *dominicense dominicense* (Gabb), small form	----	C	C	A	C	----	C	C	F	----	----	R	----	----	----	----	----	----
Americardia cf. *A. media* (Linné)	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Trigoniocardia (*Apiocardia*) cf. *T. simrothi* (Dall)	----	----	C	F	R	----	----	----	R	----	----	R	----	----	----	----	----	----
Nemocardium hadraterum Woodring, n. sp	----	----	----	----	F	F	R	----	R	----	----	----	----	----	----	----	----	----
Laevicardium laevigatum (Linné)	----	----	R	----	----	----	----	R	----	----	----	----	----	----	----	----	----	----
Mactrid[1]	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Harvella sp[1]	----	----	R	F	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Solenid[1]	----	----	----	----	----	----	----	R	----	----	----	----	----	----	----	----	----	----
Tellina (*Eurytellina*) *ophiaca* Woodring, n. sp	----	----	C	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Tellina (*Eurytellina*) *vetula* Brown and Pilsbry	----	----	----	C	F	F	F	R	R	F	----	----	----	----	----	----	----	----
Strigilla (*Strigilla*) aff. *S. carnaria* (Linné)	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Strigilla sp[1]	----	----	----	F	----	----	----	----	----	R	----	----	----	----	----	----	----	----
Psammacoma diphas Woodring, n. sp	----	----	----	----	----	----	----	----	----	R	----	----	----	----	----	----	----	----
Psammacoma talaor Woodring, n. sp	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Donax gonioides Woodring, n. sp	----	----	F	R	----	----	----	----	----	C	----	----	----	----	----	----	----	----
Donax aff. *D. asper* Hanley	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Gari (*Gobraeus*) sp[1]	----	----	R	----	----	R	----	----	----	R	----	----	----	----	----	----	----	----
Solecurtus aff. *S. broggii gatunensis* Toula	----	----	----	R	----	----	----	----	R	----	----	----	----	----	----	----	----	----
Semele chipolana Dall	----	R	----	C	R	----	----	R	----	----	----	----	----	R	----	----	----	----
Alveinus aff. *A. rotundus* Dall	----	----	----	----	----	----	----	----	----	----	----	----	R	----	----	----	----	----
Ventricolaria harrisiana (Olsson)	----	----	C	C	F	----	C	F	----	----	----	----	----	----	----	----	----	F
Tivela (*Tivela*) *mactroides* (Born), small form	----	----	R	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Pitar (*Pitar*) aff. *P. quirosanus* (H. K. Hodson)	----	R	R	----	F	----	----	----	R	----	----	----	----	----	----	----	----	----
Pitar (*Hyphantosoma*) aff. *P.* (*H.*) *centangulatus* Brown and Pilsbry	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Lamelliconcha cf. *L. aequicincta* (Spieker)	----	----	----	----	----	----	----	----	----	R	----	----	----	----	----	----	----	----
Macrocallista (*Paradione*) *maculata* (Linné)	----	----	----	C	C	----	----	C	R	----	----	----	----	----	----	----	----	----
Dosinia (*Dosinia*) *delicatissima* Brown and Pilsbry	----	R	----	R	----	----	----	C	----	----	----	----	----	----	----	----	----	----
Clementia (*Clementia*) *dariena dariena* (Conrad)	----	----	R[2]	----	R[2]	----	----	----	----	----	----	----	----	----	----	----	----	----
Chione (*Chionopsis*) *propinqua* Spieker	----	----	A	----	----	----	----	----	----	R	----	----	----	----	----	----	----	----
Chione (*Chionopsis*) *eurylopas* Woodring, n. sp	----	----	C	----	----	----	----	----	----	----	----	R	----	----	----	----	----	----
Lirophora (*Lirophora*) cf. *L.* (*L.*) *quiroensis* (H. K. Hodson)	----	R	R	A	R	----	----	----	R	----	----	----	----	----	----	----	----	----
Lirophora (*Panchione*) sp. a	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Lirophora (*Panchione*?) sp. b[1]	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Parastarte(?) sp[1]	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	A	----
Caryocorbula sp[1]	----	----	----	----	----	----	----	----	----	R	R	R	----	----	----	----	----	----
Caryocorbula? sp[1]	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Bothrocorbula (*Hexacorbula*) *cruziana* (Olsson)	----	----	A	----	----	----	R	----	----	R	F	----	----	----	----	----	----	----
Varicorbula cf. *V. vieta* (Guppy)	----	----	C	R	----	----	R	----	----	----	----	----	----	----	----	----	----	----
Varicorbula sp[1]	----	----	----	----	----	----	----	R	----	----	----	----	----	----	----	----	----	----
Unidentified tubes of wood-boring teredinids	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Kuphus "*incrassatus* Gabb"	----	----	----	----	C	----	----	F	C	----	R	----	----	----	----	----	----	----
Cyathodonta aff. *C. gatunensis* (Toula)	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----

[1] Not described.

[2] *Clementia* (*Clementia*) *dariena* (Conrad), subsp.?.

from La Boca formation

C, common; A, abundant]

Localities—Continued																										
Gaillard Cut area—Continued																					Las Cruces area		Summit area			Madden basin
101f	101g	101h	101i	101j	102	102a	113	114	115	115a	115b	116	116a	119	119a	119b	119c	120	120a	125	94	94a	127	127a	128	75
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C	----	A	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	R	----	F	----	----	----	----	F
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R	F	C	----	----	----	----	----	R	----	----	----	----	----	F	----	F	F	C	F	----	F	F	----	----	----	----
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----	----	F	----	----	----	----	----	C	F	C	----	----	C	----	----	R	R	----	----	----	----	----	----	----	----	----
----	----	A	----	----	----	----	----	----	----	----	----	----	----	R	F	F	R	C	----	----	----	----	----	----	----	----
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----	----	A	----	----	----	R	----	----	----	----	----	----	----	----	----	R	R	R	----	R	R	----	----	----	----	----
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----	----	----	F	----	----	----	----	R	----	F	R	----	F	----	----	----	----	----	----	----	R	----	R	----	----	----
----	----	----	----	----	----	----	----	----	----	----	----	----	F	----	----	----	----	----	----	----	----	----	----	----	----	----
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----	----	----	R	----	----	----	----	----	----	----	----	----	R	----	----	----	----	----	----	----	----	----	----	----	----	----
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----	----	----	----	----	----	----	----	----	----	----	----	----	R	----	----	----	----	----	----	----	----	----	----	----	----	----
----	----	C	----	----	----	----	----	F	R	C	----	----	----	----	R	----	----	----	----	----	----	----	----	----	----	----
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----	----	A	----	----	----	----	----	R	R	----	----	----	R	----	----	----	----	----	----	----	----	----	----	----	----	----
----	----	----	----	----	----	----	----	----	R	----	----	----	R	----	----	----	----	----	----	----	----	----	----	----	----	----
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----	----	F	----	----	----	----	----	R	----	C	F	----	R	F	F	----	F	----	----	----	----	----	----	----	----	----
----	----	R	----	----	----	----	----	----	----	----	----	----	----	R	sp. R	R	F	----	R	----	----	----	----	----	----	----
----	----	R	----	----	----	----	----	----	----	----	R[2]	----	R[2]	----	----	----	----	----	----	----	----	----	----	----	----	----
----	----	----	----	----	----	----	----	----	F	----	R	----	C	R	R	----	----	----	----	----	----	----	----	----	----	----
----	----	R	----	----	----	----	----	----	----	----	----	R	----	----	----	----	----	----	----	----	----	----	----	----	----	----
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----	----	R	----	----	----	----	----	F	C	----	R	----	C	----	----	----	----	----	----	R	----	----	----	----	----	----
----	----	----	C	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
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----	----	----	C	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
----	----	C	----	----	----	----	----	----	----	R	----	----	----	R	R	----	----	R	----	----	R	----	----	----	----	----
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The following table shows the occurrence elsewhere and in other Canal Zone formations of the same or related species:

Mollusks from La Boca formation and occurrence elsewhere and in other Canal Zone formations of same or related species

Species from La Boca formation	Occurrence elsewhere and in other Canal Zone formations of same or related species
Cyclopecten oligolepis (Brown and Pilsbry)?.	*C. oligolepis* (Brown and Pilsbry), Gatun formation, middle Miocene; deposits of middle Miocene age, Limón Province, Costa Rica.
Flabellipecten gatunensis protistus Woodring, n. subsp.	Caimito, Caraba and Panamá formations, late Oligocene.
Flabellipecten antiguensis (Brown).	Bohio formation, late Oligocene; shallow-water facies of Caimito formation, late Oligocene; Antigua formation, late Oligocene, Antigua; Lares limestone, late Oligocene, Puerto Rico.
Amusim toulae (Brown and Pilsbry).	Lower and upper members of Alhajuela formation, early Miocene; Gatun formation, middle Miocene; Toro limestone member of Chagres sandstone, late Miocene or early Pliocene; deposits of middle Miocene age, Limón Province, Costa Rica; deposits of middle or late Miocene age, Falcón, Venezuela; Usiacurí formation, late Miocene, Atlántico Department, Colombia.
Aequipecten canalis (Brown and Pilsbry).	Lower and upper members of Alhajuela formation, early Miocene; deposits of late Oligocene age, Falcón, Venezuela, identification doubtful; Quebradillas limestone of Vaughan (1924), early Miocene, Puerto Rico, identification doubtful.
Lepidopecten proterus Woodring, n. sp.	Culebra formation, early Miocene.
Nodipecten denaius Woodring, n. sp.	Shallow-water facies of Caimito formation, late Oligocene, identification doubtful.
"*Hyotissa*" *tryoni* Gabb	Deposits of early Miocene age, northeastern Costa Rica.
Hyotissa haitensis (Sowerby).	Lower member of Alhajuela formation, early Miocene; Gatun formation, middle Miocene; Toro limestone member of Chagres sandstone, late Miocene or early Pliocene; elsewhere late Oligocene evidently to Pleistocene.
Crassostrea cahobasensis (Pilsbry and Brown).	See Culebra formation.
Cubitostrea rugifera (Dall)	San Sebastián formation and Lares limestone, late Oligocene, Puerto Rico; early Miocene part of Cibao formation and Aguada limestone, early Miocene, Puerto Rico; Chipola and Hawthorn formations, early Miocene, Florida.
Phacoides cf. *P. pectinata domingensis* Dall.	Culebra formation, early Miocene.
Lucinisca cf. *L. calhounensis* (Dall).	*L. calhounensis* (Dall), Chipola formation, early Miocene, Florida.
Parvilucina cf. *P. yaquensis* (Gabb).	*P. yaquensis* (Gabb), Cercado formation, middle Miocene, Dominican Republic.
Pegophysema cf. *P. mauryae* (Pilsbry and Johnson).	*P. mauryae* (Pilsbry and Johnson), Miocene, Dominican Republic.
Hadralucina xenica Woodring, n. sp.	*H. augustana* (Gardner), middle Eocene, Alabama, South Carolina.
Carditamera cf. *C. tegea* (Dall).	*C. tegea* (Dall), Tampa limestone, early Miocene, Florida.
Venericardia (*Glyptoactis*) *metaicha* Woodring, n. sp.	*V.* (*G.*) *serricosta* (Heilprin), Tampa limestone, early Miocene, Florida.
Eucrassatella (*E.*) *medi-americana* (Brown and Pilsbry).	Deposits of early Miocene age, northeastern Costa Rica.
Trachycardium (*Dallocardia*) *phlyctaena* (Dall).	Bohio formation, late Oligocene, identification doubtful; Culebra formation, early Miocene; lower member of Alhajuela formation, early Miocene; Tampa limestone, early Miocene, Florida.
Trachycardium (*Dallocardia*) *dominicense dominicense* (Gabb), small form.	Upper member of Alhajuela formation, early Miocene.
Americardia cf. *A. media* (Linné).	*A. media* (Linné), middle Miocene to Holocene, western Atlantic Ocean.
Trigoniocardia (*Apiocardia*) cf. *T.* (*A.*) *simrothi* (Dall).	*T.* (*A.*) *simrothi* (Dall), Chipola formation, early Miocene, Florida; lower member of Alhajuela formation, early Miocene, identification doubtful.
Nemocardium hadraterum Woodring, n. sp.	*N. nicolletti* (Conrad), late Eocene, Louisiana and Mississippi.
Laevicardium laevigatum (Linné).	Upper member of Alhajuela formation, lower Miocene; Gatun formation, middle Miocene; elsewhere late Oligocene to Holocene, western Atlantic Ocean.
Tellina (*Eurytellina*) *ophiaca* Woodring, n. sp.	Culebra formation, early Miocene.
Tellina (*Eurytellina*) *vetula* Brown and Pilsbry.	*T.* (*E.*) *ophiaca* Woodring, n. sp., Culebra formation, early Miocene.

Mollusks from La Boca formation and occurrence elsewhere and in other Canal Zone formations of same or related species—Continued

Species from La Boca formation	Occurrence elsewhere and in other Canal Zone formations of same or related species
Strigilla (*Strigilla*) aff. *S.* (*S.*) *carnaria* (Linné).	*S.* (*S.*) *carnaria* (Linné), middle Miocene to Holocene, Caribbean region.
Psammacoma diphas Woodring, n. sp.	*P. gatunensis* (Toula), Gatun formation, middle Miocene, Culebra formation, early Miocene.
Psammacoma talaor Woodring, n. sp.	*P. olivella* (Dall), Bowden formation, middle Miocene, Jamaica.
Donax gonioides Woodring, n. sp.	*D. striata* (Linné), Holocene, Caribbean region.
Donax aff. *D. asper* Hanley	*D. asper* Hanley, Holocene, eastern Pacific Ocean.
Solecurtus aff. *S. broggii gatunensis* Toula.	*S. broggii gatunensis* Toula, Gatun formation, middle Miocene; deposits of middle Miocene age, Limón Province, Costa Rica.
Semele chipolana Dall	Upper member of Alhajuela formation, early Miocene; Chipola formation, early Miocene, Florida; Oak Grove sand member of Shoal River formation, middle Miocene, Florida.
Alveinus aff. *A. rotundus* Dall.	*A. rotundus* Dall, Chipola formation, early Miocene, Florida; Gatun formation, middle Miocene; Shoal River formation, middle Miocene, Florida; Angostura formation, middle Miocene, Ecuador.
Ventricolaria harrisiana (Olsson).	Lower member of Alhajuela formation, early Miocene; Chipola formation, early Miocene, Florida; Cantaure formation, middle Miocene, Falcón, Venezuela. Limónes formation, late Miocene, Limón Province, Costa Rica.
Tivela (*Tivela*) *mactroides* (Born), small form.	*T.* (*T.*) *mactroides* (Born), middle Miocene to Holocene, Caribbean region.
Pitar (*Pitar*) aff. *P.* (*P.*) *quirosanus* (H. K. Hodson).	*P.* (*P.*) *quirosanus* (H. K. Hodson), early Miocene, Zulia, Venezuela; Culebra formation, early Miocene.
Pitar (*Hyphantosoma*) aff. *P.* (*H.*) *centangulatus* Brown and Pilsbry.	*P.* (*H.*) *centangulatus* Brown and Pilsbry, Gatun formation middle Miocene.
Lamelliconcha cf. *L. aequicincta* (Spieker).	*L. aequicincta* (Spieker), upper part of Zorritos formation, middle Miocene, Perú; lower member of Alhajuela formation, early Miocene.
Macrocallista (*Paradione*) *maculata* (Linné).	Early Miocene to Holocene, Caribbean region.
Dosinia (*Dosinia*) *delicatissima* Brown and Pilsbry.	Upper member of Alhajuela formation, early Miocene; Gatun formation, middle Miocene; elsewhere early Miocene to late Miocene.
Clementia (*Clementia*) *dariena dariena* (Conrad).	Gatun formation, middle Miocene; elsewhere early Miocene to late Miocene.
Chione (*Chionopsis*) *propinqua* Spieker.	Lower part of Zorritos formation, early Miocene, Perú; Subibaja formation, early Miocene, Ecuador; Progreso and Daule formations, middle Miocene, Ecuador.
Lirophora (*Lirophora*) cf. *L.* (*L.*) *quirosensis* (H. K. Hodson).	*L.* (*L.*) *quirosensis* (H. K. Hodson), early Miocene, Zulia, Venezuela; Culebra formation, early Miocene.
Bothrocorbula (*Hexacorbula*) *cruziana* (Olsson).	Lower part of Zorritos formation, early Miocene, Perú; Culebra formation, early Miocene.
Kuphus "incrassatus Gabb"	See Culebra formation.
Cyathodonta aff. *C. gatunensis* (Toula).	*C. gatunensis* (Toula), upper member of Alhajuela formation, early Miocene; Gatun formation, middle Miocene; Toro limestone member of Chagres sandstone, late Miocene or early Pliocene.

EMPERADOR LIMESTONE MEMBER

The following table includes 17 species from the Emperador limestone member of the La Boca formation described in the present chapter, making a total of 25 species for the member. As outlined on pages 311–313 of P 306–D, limestones at higher and lower stratigraphic levels than the Emperador are exposed in the Las Cascadas Reach. The Emperador, however, is the only limestone that contains abundant corals.

All except six of the species listed in the following table are recorded in the La Boca proper. Those so recorded are not given further consideration.

The most notable mollusk yielded by the Emperador is the big cerithid, *Campanile* cf. *C. herculeanus* (P 306–D, p. 431), collected at locality 117c.

Pelecypods (Pectinidae to Teredinidae) from Emperador limestone member of La Boca formation

[R, rare; F, few; C, common]

	Localities											
	Gaillard Cut area									Madden basin		
	117a	117b	117c	118	118a	118b	123	129	129a	71	72	73
Flabellipecten antiguensis (Brown)		R								R		
Amusium toulae (Brown and Pilsbry)			R									
Amusium sp												R
Chlamys sentis (Reeve)?	F											
Chlamys sp					R							
Aequipecten canalis (Brown and Pilsbry)		C										R
Nolipecten denaius Woodring, n. sp.?											R	
Spondylus scotti Brown and Pilsbry	R	R					R			R		
Hyotissa polylopha Woodring, n. sp			F							R		
Crassostrea? sp [1]	F		F					R				
Pegophysema janus (Dall)?								R				
Venericardia sp [1]	R		R									
Venericardia (*Glyptoactis*) *stenygra* Woodring, n. sp						R						
Trachycardium (*Dallocardia*) *dominicense dominicense* (Gabb), small form	?R									?F		R
Tellina sp [1]										R		
Semele chipolana Dall						R						R
Periglypta tarquinia (Dall)	R	R						R	F			
Unidentified venerid [1]						R						
Macrocallista (*Paradione*) *maculata* (Linné)										R		
Dosinia (*Dosinia*) *delicatissima* Brown and Pilsbry										R		sp. R
Dosinia? sp [1]									R			
Cyclinella? sp [1]	R											
Kuphus "*incrassatus* Gabb"				R								

[1] Not described.

The following table shows the occurrence elsewhere and in other Canal Zone formations of the same or related species:

Mollusks from Emperador limestone member of La Boca formation, other than those recorded in La Boca proper, and occurrence elsewhere and in other Canal Zone formations of same or related species

Species from Emperador limestone member	Occurrence elsewhere and in other Canal Zone formations of same or related species
Chlamys sentis (Reeve)?	*C. sentis* (Reeve), Holocene, Caribbean region.
Hyotissa polylopha Woodring, n. sp.	*Hyotissa polylopha* Woodring, Oligocene evidently to Pleistocene.
Pegophysema janus (Dall)?	*P. janus* (Dall), Chipola formation, early Miocene, Florida; Gatun formation, middle Miocene.
Venericardia (*Glyptoactis*) *stenygra* Woodring, n. sp.	*V.* (*G.*) *metaicha* Woodring, n. sp., La Boca formation, early Miocene.
Periglypta tarquinia (Dall)	Suwannee limestone, late Oligocene, Florida, identification doubtful; San Sebastián formation, late Oligocene, Puerto Rico (Maury's record); Central Plain tuffs, early? Oligocene, Antigua; Antigua formation, late Oligocene, Antigua, identification doubtful: Tampa limestone, early Miocene, Florida; Anguilla formation early Miocene, Anguilla; deposits of middle Miocene age, Limón Province, Costa Rica.

ALHAJUELA FORMATION

LOWER MEMBER

The fauna of both the lower member and the upper member of the Alhajuela consists chiefly of pelecypods. The 27 species of the lower member (of a total of 35 species) described in the present chapter are listed in the following table.

Nodipecten clydonus is a species of the *N. magnificus* group but not a typical species of that group. *Anomia peruviana gabbi* includes valves of bizarre shape. The earliest occurrence of *Florimetis trinitaria* is in the lower member.

Pelecypods (Pectinidae to Hiatellidae) from lower member of Alhajuela formation

[R, rare; F, few; C, common]

	Localities														
	65	66	74	74a	76	77	78	79	80	81	82	82a	83	84	84a
Pecten (Oppenheimopecten) colpotus Woodring, n. sp	----	----	----	----	----	----	----	--------	----	----	F	----	R	----	----
Flabellipecten gatunensis gatunensis (Toula)	----	----	----	----	C	----	----	R	R	R	C	----	----	----	R
Amusium toulae (Brown and Pilsbry)	----	----	----	----	F	----	----	--------	----	----	----	----	----	----	----
Aequipecten canalis (Brown and Pilsbry)	R	F	----	----	----	?R	----	R	C	----	C	----	----	F	----
Nodipecten clydonus Woodring, n. sp	----	----	----	----	F	----	----	--------	----	----	----	----	----	----	----
Anomia peruviana gabbi Pilsbry and Johnson	----	----	----	----	----	----	F	--------	----	----	----	----	C	----	----
Hyotissa haitensis (Sowerby)	----	----	----	----	C	----	----	--------	----	----	----	----	----	----	----
Crassostrea cahobasensis (Pilsbry and Brown)	----	----	C	----	----	----	----	--------	----	----	----	----	F	----	----
Diplodonta? sp [1]	----	----	----	----	----	----	----	R	----	----	----	----	----	----	----
Trachycardium (Dallocardia) phlyctaena (Dall)	----	----	----	----	----	----	----	R	----	----	----	----	----	----	----
Trigoniocardia (Apiocardia) cf. *T. simrothi* (Dall)?	----	----	----	----	----	----	----	R	----	----	----	----	----	----	----
Psammacoma sp [1]	----	----	----	----	----	----	----	--------	----	----	----	----	----	----	R
Florimetis trinitaria (Dall)	----	----	----	----	----	----	----	--------	----	----	----	R	----	----	----
Ventricolaria harrisiana (Olsson)	----	----	----	----	----	----	----	--------	----	----	----	R	----	----	----
Tivela mactroides (Born), small form	----	----	----	----	----	----	----	R	----	----	----	----	----	----	----
Pitar sp [1]	----	----	----	----	----	----	----	F	----	----	----	----	----	----	----
Lamelliconcha cf. *L. aequicincta* (Spieker)?	----	----	----	----	----	----	----	--------	----	----	----	R	----	----	----
Macrocallista (Paradione) maculata (Linné)	----	----	----	----	----	----	----	(cf.) F	----	----	----	F	----	----	----
Chione (Chionopsis) tegulum Brown and Pilsbry	----	----	----	----	----	----	----	?F	----	----	R	----	----	----	----
Lirophora (Lirophora) falconensis (H. K. Hodson)?	----	----	----	----	----	----	----	--------	----	----	R	----	----	----	----
Panopea sp	----	----	----	----	----	----	----	C	----	----	----	F	----	----	----

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[1] Not described.

The occurrence elsewhere and in other Canal Zone formations of the same, or related species is tabulated as follows:

Mollusks from lower member of Alhajuela formation and occurrence elsewhere and in other Canal Zone formations of same, or related species

Species from lower member of Alhajuela formation	Occurrence elsewhere and in other Canal Zone formations of same or related species
Pecten (Oppenheimopecten) colpotus Woodring, n. sp.	*P. (O.) urumaconis* Harris, late Miocene, Falcón, Venezuela.
Flabellipecten gatunensis gatunensis (Toula).	*See* upper member.
Amusium toulae (Brown and Pilsbry).	*See* La Boca formation.
Aequipecten canalis (Brown and Pilsbry).	*See* La Boca formation.
Nodipecten clydonus Woodring, n. sp.	*N. magnificus* (Sowerby). Holocene, eastern Pacific Ocean.
Anomia peruviana gabbi Pilsbry and Johnson.	Gatun formation, middle Miocene; Miocene. Dominican Republic; middle Miocene deposits, Falcón, Venezuela; upper part of Zorritos formation and Montera formation, middle Miocene Perú.
Hyotissa haitensis (Sowerby).	*See* La Boca formation.
Crassostrea cahobasensis (Pilsbry and Brown).	*See* Culebra formation.
Trachycardium (Dallocardia) phlyctaena (Dall).	*See* Culebra formation.
Trigoniocardia (Apiocardia) cf. *T. (A.) simrothi* (Dall)?.	*T. (A.) simrothi* (Dall), Chipola formation, early Miocene, Florida; La Boca formation, early Miocene.
Florimetis trinitaria (Dall).	Tubará formation. middle Miocene, Atlántico Dept. Colombia; middle Miocene deposits, Falcón, Venezuela (Hodsons' record); Daule formation, middle Miocene, Ecuador (Mark's undocumented record); Usiacurí formation, late Miocene, Atlántico Dept., Colombia (Weisbord's record); Savaneta glauconitic sandstone member and Melajo clay member of Springvale formation, late Miocene, Trinidad.
Ventricolaria harrisiana (Olsson).	*See* La Boca formation.
Tivela mactroides (Born), small form.	*See* Culebra formation.
Lamelliconcha cf. *L. aequicincta* (Spieker)?.	*See* La Boca formation.
Macrocallista (Paradione) maculata (Linné).	*See* Culebra formation.
Chione (Chionopsis) tegulum Brown and Pilsbry.	Gatun formation, middle Miocene; deposits of middle Miocene age, Limón Province, Costa Rica (Olsson's record); Cantaure formation, middle Miocene, Falcón, Venezuela.
Lirophora (Lirophora) falconensis (H. K. Hodson)?.	*L. (L.) falconensis* (H. K. Hodson). Gatun formation, middle Miocene; Urumaco formation, middle or late Miocene, Falcón, Venezuela.
Panopea sp	*P. globosa* Dall, Holocene, eastern Pacific Ocean.

UPPER MEMBER

The massive sandstones of the upper member of the Alhajuela formation are conspicuous features of Madden basin. The 13 species, of a total of 18, described in the present chapter are listed in the following table.

The largest specimens of *Flabellipecten gatunensis gatunensis* are found in the upper member. That unit also contains the large *Dinocardium robustum*, a large *Dosinia* (*D.*) aff. *D. ponderosa titan*, the large *Panopea parawhitfieldi*, and its fauna, like that of two others of Miocene age under study, includes *Pholadomya*.

Pelecypods (Pectinidae to Thraciidae) from upper member of Alhajuela formation

[R, rare; F, few; C, common; A, abundant]

	Localities									
	85	85a	86	87	88	89	90	90a	91	92
Flabellipecten gatunensis gatunensis (Toula)	F	F	----	R	----	F	F	----	C	----
Amusium toulae (Brown and Pilsbry)	----	----	F	----	----	----	----	----	----	----
Aequipecten canalis (Brown and Pilsbry)	----	----	----	----	R	----	R	----	----	----
Argopecten venezuelanus (F. and H. Hodson)	A	C	----	----	----	R	F	----	----	----
Trachycardium (*Dallocardia*) *dominicense dominicense* (Gabb), small form	----	----	F	----	----	----	----	----	----	----
Dinocardium robustum [Lightfoot], small form	C	F	F	F	C	C	----	C	----	F
Laevicardium laevigatum (Linné)	R	----	----	----	----	----	----	----	----	----
Mactrid [1]	----	----	----	----	R	----	----	----	----	----
Solenid [1]	----	----	----	----	R	F	----	----	----	----
Semele chipolana Dall	----	----	----	----	----	R	----	----	----	----
Periglypta cf. *P. caribbeana* (Anderson)	----	----	----	----	----	R	----	----	----	----
Pitar (*Pitar*) cf. *P. coroanus* (H. K. Hodson)	R	----	----	----	----	----	----	----	----	----
Macrocallista (*Paradione*) *maculata* (Linné)	F	F	----	----	----	----	----	F	----	----
Dosinia (*Dosinia*) *delicatissima* Brown and Pilsbry	----	----	----	----	----	F	----	----	----	----
Dosinia (*Dosinia*) aff. *D. ponderosa titan* Maury	R	----	----	----	----	R	----	R	R	----
Cyclinella? sp [1]	----	----	----	----	----	----	----	----	----	R
Lirophora (*Panchione*) sp. a	----	----	----	----	----	----	----	----	----	R
Caryocorbula sp [1]	R	----	----	----	----	R	----	----	----	----
Bothrocorbula (*Hexacorbula*) sp [1]	----	----	----	----	----	R	----	----	----	----
Varicorbula sp [1]	----	----	----	----	----	----	----	----	----	F
Varicorbula? sp [1]	----	----	----	----	----	----	----	R	----	----
Panopea parawhitfieldi (Gardner)	----	----	----	----	----	R	----	----	----	----
Pholadomya falconensis F. and H. Hodson?	R	----	----	----	----	----	----	R	R	----
Cyathodonta gatunensis (Toula)	----	----	----	----	----	R	----	----	----	----

[1] Not described.

The following table shows the occurrence elsewhere and in other Canal Zone formations of the same or related species.

Mollusks from upper member of Alhajuela formation and occurrence elsewhere and in other Canal Zone formations of same or related species

Species from upper member of Alhajuela formation	Occurrence elsewhere and in other Canal Zone formations of same or related species
Flabellipecten gatunensis gatunensis (Toula)	Lower member of Alhajuela formation, early Miocene; Gatun formation, middle Miocene; middle Miocene deposits, central Costa Rica; Piojó formation, Atlántico Dept., Colombia; middle Miocene deposits, Falcón, Venezuela; Angostura formation, middle Miocene, Ecuador; Limónes formation, late Miocene, Bocas del Toro area, Panamá (Olsson's record).
Amusium toulae (Brown and Pilsbry).	*See* La Boca formation.
Aequipecten canalis (Brown and Pilsbry).	*See* La Boca formation.
Argopecten venezuelanus (F. and H. Hodson).	Deposits of middle or late Miocene age, Falcón, Venezuela.
Trachycardium (*Dallocardia*) *dominicense dominicense* (Gabb), small form.	*See* La Boca formation.
Dinocardium robustum [Lightfoot], small form.	Caloosahatchee formation, Pliocene, Florida; Holocene, New Jersey to Belize.
Laevicardium laevigatum (Linné).	*See* La Boca formation.
Semele chipolana Dall	*See* La Boca formation.
Periglypta cf. *P. caribbeana* (Anderson).	*P. caribbeana* (Anderson), middle and late Miocene, Atlántico Dept., Colombia; Cercado formation, middle Miocene, Dominican Republic; Limónes formation, late Miocene, Bocas del Toro area, Panamá.
Pitar (*Pitar*) cf. *P. coroanus* (H. K. Hodson).	*P.* (*P.*) *coroanus* (H. K. Hodson), middle Miocene, Falcón, Venezuela.
Macrocallista (*Paradione*) *maculata* (Linné).	Early Miocene to Holocene, Caribbean region.
Dosinia (*Dosinia*) *delicatissima* Brown and Pilsbry.	*See* La Boca formation.
Dosinia (*Dosinia*) aff. *D. ponderosa titan* Maury.	*D.* (*D.*) *titan* Maury, Savaneta glauconitic sandstone member of Springvale formation, late Miocene, Trinidad; Gatun formation, middle Miocene.
Panopea parawhitfieldi (Gardner).	Gatun formation, middle Miocene, Oak Grove sand member of Shoal River formation, middle Miocene, Florida.
Pholadomya falconensis F. and H. Hodson?.	*P. falconensis* F. and H. Hodson, presumably La Vela formation, late Miocene, Falcón, Venezuela.
Cyathodonta gatunensis (Toula).	Gatun formation, middle Miocene; Toro limestone member of Chagres sandstone, late Miocene or early Pliocene.

GATUN FORMATION

As in other chapters, the bulk of the taxonomic part of the present chapter is devoted to the fauna of the richly fossiliferous Gatun formation: 121 species and subspecies of a total of 396 for that formation. Locality 138c yielded 197 species and subspecies. Those species and subspecies covered in the present chapter are listed in the table on p. 560–568.

The following species and subspecies are especially characteristic of the Gatun:

Flabellipecten gatunensis gatunensis (Toula)
Aequipecten plurinominis (Pilsbry and Johnson)
Lepidopecten scissuratus (Dall)
Hyotissa haitensis (Sowerby)
Trachycardium (*Dallocardia*) *dominicense* (Gabb)
Tellina (*Miratellina*) *anaxia* Woodring, n. sp.
Psammacoma gatunensis (Toula)
Semele laevis costaricensis Olsson
Agriopoma (*Pitarella*) *gatunensis* (Dall)
Clementia (*Clementia*) *dariena dariena* (Conrad)
Lirophora (*Panchione*) *mactropsis* (Conrad)
Bothrocorbula (*Hexacorbula*) *gatunensis* (Toula)

The occurrence elsewhere and in other Canal Zone formations of the same or related forms are tabulated as follows:

Mollusks from Gatun formation and occurrence elsewhere and in other Canal Zone formations of same or related forms

Species from Gatun formation	Occurrence elsewhere and in other Canal Zone formations of same, or related forms
Cyclopecten oligolepis (Brown and Pilsbry).	Deposits of middle Miocene age, Limón Province, Costa Rica (Olsson's record).
Pecten (*Euvola*) *bowdenensis* Dall.	Bowden formation, middle Miocene, Jamaica.
Flabellipecten gatunensis gatunensis (Toula).	*See* upper member of Alhajuela formation.
Flabellipecten gatunensis tapeinus Woodring, n. subsp.	Chagres sandstone, late Miocene or early Pliocene.
Amusium toulae (Brown and Pilsbry).	*See* La Boca formation.
Aequipecten plurinominis (Pilsbry and Johnson).	Gurabo formation, middle Miocene, Dominican Republic; Bowden formation, middle Miocene, Jamaica; middle Miocene, Falcón, Venezuela; Progreso formation, middle Miocene, Ecuador.
Lepidopecten scissuratus (Dall).	Middle Miocene, Falcón, Venezuela.
Argopecten levicostatus (Toula).	Deposits of middle Miocene age, Limón Province, Costa Rica; Urumaco formation, middle or late Miocene, Falcón, Venezuela.
Anomia peruviana gabbi Pilsbry and Johnson.	*See* lower member of Alhajuela formation.
Anomia simplex d'Orbigny ----	Late early Miocene to Holocene, Caribbean region.
Limatula asymbleta Woodring, n. sp.	Bowden formation, middle Miocene, Jamaica.
Pycnodonte (*Pycnodonte*?) sp.	Undescribed species in Druid Wilson's (U.S. Geol. Survey) collection from middle Miocene Pungo River formation of North Carolina.
Hyotissa haitensis (Sowerby)	*See* La Boca formation.
Crassostrea cahobasensis (Pilsbry and Brown).	*See* Culebra formation.
Ostrea equestris heothina Woodring, n. subsp.	*Ostrea equestris equestris* Say, Holocene, western Atlantic Ocean.
Lopha frons (Linné) -------	Middle Miocene to Holocene, Caribbean region.
Lucina (*Lepilucina*) *gratis* Olsson.	Angostura formation, middle Miocene, Ecuador.
Bellucina actinus (Dall) ---	Bowden formation, middle Miocene, Jamaica; Cercado formation, middle Miocene, Dominican Republic (Maury's record); Limónes formation, late Miocene, Bocas del Toro area, Panamá.
Lucinisca bocasensis (Olsson).	Limónes formation, late Miocene, Bocas del Toro area, Panamá.
Miltha chipolana (Dall)? ---	*M. chipolana* (Dall), Chipola formation, early Miocene, Florida.
Pegophysema janus (Dall) -	Chipola formation, early Miocene, Florida.
Divaricella cf. *D. comis* Olsson.	*D. comis* Olsson Angostura formation, middle Miocene, Ecuador.
Diplodonta (*D.*) cf. *D. minor* Dall.	*D.* (*D.*) *minor* Dall, Bowden formation, middle Miocene, Jamaica.
Timothynus capuloides (Gabb).	Cercado formation, middle Miocene, Dominican Republic; Bowden formation, middle Miocene, Jamaica.
Temblornia virgata (Gardner).	Shoal River formation, middle Miocene, Florida; Subibaja formation, early Miocene, Ecuador.
Venericardia (*Glyptoactis*) *aversa* Pilsbry and Johnson.	Miocene, Dominican Republic.
Pleuromeris aff. *P. acaris* (Dall).	*P. acaris* (Dall), Bowden formation, middle Miocene, Jamaica; Cantaure formation, middle Miocene, Falcón, Venezuela; Urumaco formation, middle or late Miocene, Falcón, Venezuela.
Chama berjadinensis F. Hodson.	Cantaure formation, middle Miocene, Falcón, Venezuela; Urumaco formation, middle or late Miocene, Falcón, Venezuela.
Arcinella arcinella (Linné), small form.	Large form, middle Miocene deposits, Limón Province, Costa Rica, Cantaure formation, middle Miocene, Falcón, Venezuela; Angostura formation, middle Miocene, Ecuador.

Pelecypods (Propeamussiidae to Cuspidariidae, Manzanellidae), a cephalopod (Nautilidae), and additional gastropods from Gatun formation

[R, rare; F, few; C, common; A, abundant]

	Localities																																		
	Lower part																Middle part																		
																	Eastern area																		
	134	135	136	136a	137	137a	138	138a	138b	138c	138d	138e	138f	138g	138h	138i	139	139a	139b	139c	139d	139e	139f	139g	139h	140	141	142	143	143a	144	144a	144b	144c	144d
Cyclopecten oligolepis (Brown and Pilsbry)	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	F	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------
Pecten (*Oppenheimopecten*) *reliquus* (Brown and Pilsbry)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------
Pecten (*Euvola*) *bowdenensis* Dall	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------
Flabellipecten gatunensis gatunensis (Toula)	--	--	--	--	--	--	F	--	--	C	F	--	R	--	F	--	--------	--	--	--	R	--	--	--	--	R	F	--	F	--	F	F	F	--	R
Flabellipecten gatunensis tapeinus Woodring, n. subsp	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	F	--	--	--	--	--	--	--	--	--	--	--------
Amusium toulae (Brown and Pilsbry)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	sp. R
Aequipecten plurinominis (Pilsbry and Johnson)	--	--	--	--	--	--	R	--	--	R	--	--	--	--	--	--	--------	--	F	F	--	--	--	F	--	R	C	--	F	R	C	F	F	--	--------
Lepidopecten scissuratus (Dall)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	--	--	--	--	F	--	--	--	--	--	--	--------
Leptopecten ecnomius Woodring, n. sp	--	--	--	F	A	R	A	C	R	A	A	R	C	R	C	--	--------	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------
Argopecten levicostatus (Toula)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------
Dimya phaidra Woodring, n. sp	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------
Anomia peruviana gabbi Pilsbry and Johnson	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--------
Anomia simplex d'Orbigny	--	--	--	--	--	--	--	--	--	--	R	R	--	--	--	--	--------	--	R	--	--	--	R	--	R	--	C	--	--	--	--	C	--	--	--------
Limatula asymbleta Woodring, n. sp	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------
Limatula sp	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------
Pycnodonte (*Pycnodonte*?) sp	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------
Hyotissa haitensis (Sowerby)	--	--	--	--	--	--	--	--	--	C	R	--	R	--	--	--	--------	--	C	C	--	C	R	--	--	--	F	--	R	--	--	--	--	--	--------
Crassostrea cahobasensis (Pilsbry and Brown)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------
Ostrea equestris heothina Woodring, n. subsp	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	--	--	F	C	R	--	--	--	A	--	--	F
Lopha frons (Linné)	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--------	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------
Lucina (*Lepilucina*) *gratis* Olsson	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	C	--	--	--	--	--	--	--	--	--	--	--------
Bellucina actinus (Dall)	--	--	--	C	F	--	F	A	F	A	C	--	R	R	F	--	--------	--	A	A	--	R	--	C	--	--	--	--	--	--	--	--	--	--	--------
Lucinisca bocasensis (Olsson)	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--------	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------
Miltha chipolana (Dall)?	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------
Lucinoma sp. b	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------
"*Lucinoma*" sp	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--------	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------
Megaxinus? sp[1]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------
Pegophysema janus (Dall)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	F	--	--	--	--	--	--	--	--	--	--	--------
Divaricella cf. *D. comis* Olsson	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	F	--	--	--	--	R	--	R	--	--	--	--------
Diplodonta (*Diplodonta*) *homalostriata* Woodring	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--------	--	--	--	--	--	--	C	--	--	--	--	R	--	--	--	--	--	--------
Diplodonta sp[1]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------
Diplodonta (*Diplodonta*) cf. *D. minor* Dall	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------
Timothynus capuloides (Gabb)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------
Temblornia virgata (Gardner)	--	--	--	R	--	--	--	--	--	--	--	--	--	R	--	--	--------	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------
Carditamera sp	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--------
Venericardia (*Glyptoactis*) *aversa* Pilsbry and Johnson	--	R	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--------	--	--	--	--	--	--	--	--	--	--	--	--	--	F	--	--	--	R
Pleuromeris aff. *P. acaris* (Dall)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------
Chama berjadinensis F. Hodson	--	--	--	--	--	--	--	R	--	F	--	--	--	--	--	--	--------	--	--	C	--	C	R	--	R	--	--	--	--	--	--	--	--	--	--------
Arcinella arcinella (Linné), small form	--	--	--	--	--	--	--	R	--	C	F	--	--	--	--	--	--------	--	F	F	--	F	--	--	--	--	--	--	--	--	--	--	--	--	--------
Arcinella arcinella (Linné)?	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------
Eucrassatella (*Eucrassatella*) sp	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------
Eucrassatella (*Hybolophus*) *elassa* Woodring, n. sp	--	--	F	C	--	R	A	A	--	A	A	--	C	F	C	--	--------	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------
Eucrassatella (*Hybolophus*) *venezuelana* (F. Hodson)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------
Crassinella martinicensis (d'Orbigny)?	--	--	--	--	--	--	F	R	--	C	--	--	--	--	--	--	--------	--	--	F	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------
Trachycardium (*Trachycardium*) cf. *T. isocardia* (Linné)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------
Trachycardium (*Dallocardia*) *dominicense dominicense* (Gabb)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	F	--	--	R	--	F	--	R	R	--	--	--------
Trachycardium (*Dallocardia*) *dominicense hadratatum* Woodring, n. subsp	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------
Trachycardium (*Dallocardia*) *baiterum* Woodring, n. sp	--	--	--	--	--	--	R	F	--	A	A	--	--	--	R	--	--------	--	R	C	--	C	R	C	--	R	--	--	--	--	--	--	--	--	--------
Trachycardium (*Phlogocardia*) *stiriatum* (Brown and Pilsbry)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------
Trachycardium (*Mexicardia*) *dominicanum costaricanum* (Olsson)	--	--	R	F	F	R	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------

See footnotes at end of table.

Pelecypods (Propeamussiidae to Cuspidariidae, Manzanellidae), a cephalopod (Nautilidae), and additional gastropods from Gatun formation—Continued

[R, rare; F, few; C, common; A, abundant]

	Localities																																		
	Lower part																Middle part																		
																	Eastern area																		
	134	135	136	136a	137	137a	138	138a	138b	138c	138d	138e	138f	138g	138h	138i	139	139a	139b	139c	139d	139e	139f	139g	139h	140	141	142	143	143a	144	144a	144b	144c	144d
Trigoniocardia (*Trigoniocardia*?) *minutissima* (Toula)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Trigoniocardia (*Apiocardia*) *aminensis* (Dall)	--	--	C	--	C	R	A	--	--	A	A	C	C	C	--	--	--	--	C	C	--	R	--	R	--	F	--	--	--	--	--	--	--	--	--
Lophocardium gurabicum (Maury)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Dinocardium cf. *D. cabezai* (Gardner)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Laevicardium laevigatum (Linné)	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	R	--
Mactrellona alata (Spengler)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	R	--	--	--
Mulinia aff. *M. lateralis* (Say)	--	--	--	--	--	--	--	R	--	C	F	--	R	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Mulinia aff. *M. cleryana* (d'Orbigny)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Harvella elegans elegans (Sowerby)	R	--	C	F	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R
Raeta hasletti (Anderson)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Raeta undulata (Gould)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Ervilia valhosierr Gardner	--	--	--	--	--	C	A	A	C	A	A	R	C	A	--	--	--	--	--	A	--	R	F	--	--	--	--	--	--	--	--	R	--	F	F
Solen (*Solena*) *obliquus rudis* C. B. Adams	--	--	--	--	--	--	--	--	--	F	--	--	--	--	--	--	--	--	F	R	--	F	--	--	--	--	--	--	--	--	--	--	--	--	--
Tellina (*Phyllodina*) *lepidota* Dall	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Tellina (*Merisca*) *cristallina* Spengler	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Tellina (*Merisca*) *acquistriata* Say	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Tellina (*Miratellina*) *anaxia* Woodring, n. sp	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Tellina (*Eurytellina*) *punicea* Born	--	R	F	C	--	--	R	R	--	C	F	--	--	--	--	--	--	--	F	--	--	--	--	R	--	--	--	--	--	--	--	--	--	F	--
Tellina (*Eurytellina*) *nitens* C. B. Adams	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Tellina (*Eurytellina*) *angulosa costaricana* Olsson	--	--	--	--	--	--	R	--	--	F	F	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	R	--	R	--
Tellina sp[12]	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Tellidora cristata (Récluz)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Strigilla (*Strigilla*) *carnaria* (Linné)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Psammacoma gatunensis (Toula)	--	--	--	R	--	--	R	--	--	F	--	--	--	--	--	--	--	--	--	R	--	--	--	C	--	R	--	--	--	R	--	R	--	R	--
Psammotreta hadra Woodring, n. sp	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Donax carinatus palaius Woodring, n. subsp	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sanguinolaria (*Sanguinolaria*) aff. *S. tellinoides* A. Adams	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Solecurtus broggii gatunensis Toula	--	--	--	--	R	--	--	--	--	R	--	R	--	--	--	--	--	--	--	--	--	--	R	R	--	--	--	--	--	--	--	--	--	--	--
Tagelus (*Mesopleura*) *divisus* (Spengler)?	--	--	--	--	--	--	--	--	--	R	R	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Semele cf. *S. perlamellosa* Heilprin	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Semele laevis costaricensis Olsson	--	--	F	C	--	--	R	--	--	F	--	--	R	--	--	R	--	--	--	--	--	--	--	C	--	--	--	--	R	--	--	R	--	--	--
Semele sayi Toula	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Abra (*Abra*) *lioica* (Dall)?	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Alveinus rotundus Dall	--	--	--	F	--	--	A	A	C	A	C	A	C	C	A	--	--	--	--	A	--	R	F	A	--	--	--	--	--	--	--	--	--	--	--
Ventricolaria sp	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Gouldia costaricensis (Olsson)	--	--	--	--	--	--	--	--	--	A	--	R	--	--	--	--	--	--	A	A	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Tivela mactroides (Born), small form	--	--	R	--	R	--	--	--	--	F	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Transennella cola Woodring, n. sp	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pitar (*Hyphantosoma*) *centangulatus* Brown and Pilsbry	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Hysteroconcha sp	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Hysteroconcha rosea vanwinkleae (Olsson)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Lamelliconcha cora (Brown and Pilsbry)	--	--	C	--	F	--	F	--	--	C	F	R	--	--	R	--	C	--	--	--	--	--	--	F	--	--	R	--	R	--	--	R	--	--	--
Macrocallista (*Paradione*) *maculata* (Linné)	--	--	C	C	A	R	C	C	R	A	A	C	C	R	F	--	C	--	A	C	--	F	R	R	--	--	--	--	C	--	--	--	--	--	--
Costacallista leiotera Woodring, n. sp	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Agriopoma (*Pitarella*) *gatunensis* (Dall)	--	--	--	--	--	--	R	--	--	C	--	R	--	--	R	--	R	--	A	A	R	C	--	C	C	R	--	R	R	--	--	--	--	--	--
Dosinia (*Dosinia*) *delicatissima* Brown and Pilsbry	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	F	--	F	--	R	R	--	--	--
Dosinia (*Dosinia*) aff. *D. ponderosa titan* Maury	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cyclinella cyclica (Guppy)	--	--	F	F	--	R	--	R	--	F	--	R	--	--	--	--	R	--	--	F	--	F	--	C	F	F	R	--	R	--	--	F	--	--	--
Clementia (*Clementia*) *dariena dariena* (Conrad)	--	--	--	R	--	R	--	R	--	A	--	C	--	--	R	--	--	--	R	C	--	C	F	F	R	R	--	--	C	--	R	--	--	--	--
Chione (*Chionopsis*) *tegulum* Brown and Pilsbry	--	R	C	C	C	R	C	C	--	A	C	--	C	C	C	--	C	--	--	R	--	R	--	C	--	R	F	--	C	--	R	C	--	--	--
Lirophora (*Lirophora*) *falconensis* (H. K. Hodson)	--	--	--	--	R	F	R	--	--	A	A	--	--	--	C	--	--	--	C	C	--	R	--	--	R	--	--	--	--	--	C	--	--	--	--
Lirophora (*Panchione*) *mactropsis* (Conrad)	--	--	--	--	--	--	R	F	--	A	R	C	F	--	R	--	--	--	--	A	--	C	A	F	A	R	--	C	--	--	--	--	--	--	--
Nioche (*Antinioche*) *dolicha* Woodring, n. sp	--	--	--	--	--	--	--	--	--	R	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Parastarte psila Woodring, n. sp	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Petricola millestriata Brown and Pilsbry	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Rupellaria typica (Jonas)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Caryocorbula oropendula stena Woodring, n. subsp	--	--	A	F	A	--	C	A	--	A	A	C	R	--	--	--	C	--	A	C	F	F	R	--	--	--	--	--	--	--	--	--	--	--	--

See footnotes at end of table.

Pelecypods (Propeamussiidae to Cuspidariidae, Manzanellidae), a cephalopod (Nautilidae), and additional gastropods from Gatun formation—Continued

[R, rare; F, few; C, common; A, abundant]

	Localities																																		
	Lower part																Eastern area																		
																	Middle part																		
	134	135	136	136a	137	137a	138	138a	138b	138c	138d	138e	138f	138g	138h	138i	139	139a	139b	139c	139d	139e	139f	139g	139h	140	141	142	143	143a	144	144a	144b	144c	144d
Caryocorbula oropendula dolicha Woodring, n. subsp	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Caryocorbula cf. *C. manzanillensis* (Maury)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Caryocorbula prenasuta Olsson	--	--	A	F	--	--	--	--	R	C	C	--	R	R	--	--	sp. R	--	--	--	--	--	--	R	--	R	--	--	--	--	--	--	--	R	R
Bothrocorbula (Hexacorbula) gatunensis (Toula)	--	--	--	--	--	--	A	A	F	A	A	F	C	C	--	--	--	--	--	F	--	--	--	C	--	--	--	R	--	--	--	--	--	--	F
Varicorbula disparilis (d'Orbigny), small form	--	--	--	--	--	--	R	R	--	F	--	--	--	R	--	--	--	--	C	F	--	R	--	R	R	--	--	--	--	--	--	--	--	--	--
Varicorbula islatrinitatis (Maury)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	A	A
Panopea parawhitfieldi (Gardner)	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Martesia sanctipauli Maury	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Unidentifiable tubes of wood-boring teredinids	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Kuphus "incrassatus Gabb"	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pholadomya falconensis F. and H. Hodson	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pandora (Pandorella) inconspicua Gabb	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cyathodonta? cf. *C.*? *dolicha* Woodring, n. sp	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--
Cyathodonta gatunensis (Toula)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cuspidaria cf. *C. obesa* (Lovén)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cardiomya mansfieldi (Olsson and Harbison)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Nucinella cf. *N. woodii* (Dall)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aturia curvilineata Miller and Thompson?	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

See footnotes at end of table.

Pelecypods (Propeamussiidae to Cuspidariidae, Manzanellidae), a cephalopod (Nautilidae), and additional gastropods from Gatun formation—Continued

[R, rare; F, few; C, common; A, abundant]

	Localities—Continued																																
	Middle part—Continued																																
	Eastern area—Continued																																
	145	146	147	147a	147b	147c	147d	147e	147f	147g	147h	147i	147j	149	150	150a	151	152	153	153a	154	155	155a	155b	155c	156	157	158	159	159b	159c	159d	Other collections
Cyclopecten oligolepis (Brown and Pilsbry)	--	--	--	--	C	--	--	--	F	R	--	--	--	--	--	--	--	--	--	--	--	--	C	--	A	--	R	--	--	--	--	--	--
Pecten (*Oppenheimopecten*) *reliquus* (Brown and Pilsbry)	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R
Pecten (*Euvola*) *bowdenensis* Dall	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Flabellipecten gatunensis gatunensis (Toula)	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	F	--	F	--	--	--	--	R	--	--	--	--
Flabellipecten gatunensis tapeinus Woodring, n. subsp	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Amusium toulae (Brown and Pilsbry)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	sp. R	--	--	F	R	--	F	--	--	--	--	sp. R	--	--	--	--
Aequipecten plurinominis (Pilsbry and Johnson)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Lepidopecten scissuratus (Dall)	--	--	--	--	C	--	--	--	--	--	F	--	--	--	--	--	R	--	--	R	--	F	R	C	--	--	--	--	--	--	--	F	--
Leptopecten ecnomius Woodring, n. sp	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Argopecten levicostatus (Toula)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	C	F	R	F	--	--	--	--	F	--	--	R	--
Dimya phaidra Woodring, n. sp	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Anomia peruviana gabbi Pilsbry and Johnson	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Anomia simplex d'Orbigny	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--
Limatula asymbleta Woodring, n. sp	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
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Pycnodonte (*Pycnodonte*?) sp	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Hyotissa haitensis (Sowerby)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	F	R	R	R	--	--	--	--	--	R	--	--	--
Crassostrea cahobasensis (Pilsbry and Brown)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Ostrea equestris heothina Woodring, n. subsp	--	--	--	R	A	--	--	C	R	F	--	--	R	--	--	--	R	--	R	--	R	--	--	--	F	--	--	--	--	--	--	--	--
Lopha frons (Linné)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Lucina (*Lepilucina*) *gratis* Olsson	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Bellucina actinus (Dall)	--	A	--	--	A	--	--	--	C	A	A	--	--	--	--	--	--	--	--	C	--	C	C	F	A	--	R	--	--	--	--	F	--
Lucinisca bocasensis (Olsson)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--
Miltha chipolana (Dall)?	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	R	--	R	--	--	--	--	--	--	--	--
Lucinoma sp. b	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
"*Lucinoma*" sp	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Megaxinus? sp [1]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R
Pegophysema janus (Dall)	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	R	--	--	C	--	F	R	R	R	--	--	R	--	--	--
Divaricella cf. *D. comis* Olsson	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Diplodonta (*Diplodonta*) *homalostriata* Woodring	--	--	R	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	C	--
Diplodonta sp [1]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Diplodonta (*Diplodonta*) cf. *D. minor* Dall	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--
Timothynus capuloides (Gabb)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--
Temblornia virgata (Gardner)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Carditamera sp	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Venericardia (*Glyptoactis*) *aversa* Pilsbry and Johnson	--	--	--	--	F	--	--	--	--	F	--	--	--	--	F	--	--	--	--	--	--	R	R	R	--	--	--	--	--	--	--	R	--
Pleuromeris aff. *P. acaris* (Dall)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Chama berjadinensis F. Hodson	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--
Arcinella arcinella (Linné), small form	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	C	R	C	R	--	R	--	--	--	--	F	--
Arcinella arcinella (Linné)?	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Eucrassatella (*Eucrassatella*) sp	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	F	--	--	--	--	--	--	--	--	--
Eucrassatella (*Hybolophus*) *classa* Woodring, n. sp	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Eucrassatella (*Hybolophus*) *venezuelana* (F. Hodson)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--
Crassinella martinicensis (d'Orbigny)?	--	--	--	--	F	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--
Trachycardium (*Trachycardium*) cf. *T. isocardia* (Linné)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Trachycardium (*Dallocardia*) *dominicense dominicense* (Gabb)	R	--	C	R	R	F	R	--	--	R	--	--	--	--	--	--	R	--	C	R	--	F	--	R	--	--	--	R	C	--	--	R	--
Trachycardium (*Dallocardia*) *dominicense hadratatum* Woodring, n. subsp	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Trachycardium (*Dallocardia*) *baiterum* Woodring, n. sp	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Trachycardium (*Phlogocardia*) *stiriatum* (Brown and Pilsbry)	--	R	--	R	R	--	--	--	--	--	R	--	--	--	--	--	R	--	--	--	--	F	C	C	--	R	C	--	R	R	--	--	--
Trachycardium (*Mexicardia*) *dominicanum costaricanum* (Olsson)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	F	R	--	--	--	--	--	--	--	--	--	--
Trigoniocardia (*Trigoniocardia*?) *minutissima* (Toula)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R

See footnotes at end of table.

Pelecypods (Propeamussiidae to Cuspidariidae, Manzanellidae), a cephalopod (Nautilidae), and additional gastropods from Gatun formation—Continued

[R, rare; F, few; C, common; A, abundant]

	Localities—Continued																															
	Middle part—Continued																															
	Eastern area—Continued																															
	145	146	147	147a	147b	147c	147d	147e	147f	147g	147h	147i	147j	149	150	150a	151	152	153	153a	154	155	155a	155b	155c	156	157	158	159	159b	159c	159d	Other collections
Trigoniocardia (Apiocardia) aminensis (Dall)	R	R	R	--	R	R	R	--	--	--	R	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--------	--	--	F	--------
Lophocardium gurabicum (Maury)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	R	--	--	--	--	--------	--	--	--	--------
Dinocardium cf. *D. eabezai* (Gardner)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--------
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Mactrellona alata (Spengler)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	R	--	--	--	--	--	R	--	--	--	--------	--	--	--	--------
Mulinia aff. *M. lateralis* (Say)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--------
Mulinia aff. *M. cleryana* (d'Orbigny)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	R	--	--	--	--	--	--	--------	--	R	--	--------
Harvella elegans elegans (Sowerby)	R	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--------	--	--	--	R	--	--	--	--	--	--	--------	--	--	--	--------
Raeta hasletti (Anderson)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--------
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Solen (Solena) obliquus rudis C. B. Adams	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	--	--	R	--	--------	--	--	--	--------
Tellina (Phyllodina) lepidota Dall	--	--	--	--	--	--	--	R	R	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	--	--	R	--	--------	--	--	R	--------
Tellina (Merisca) cristallina Spengler	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--------
Tellina (Merisca) aequistriata Say	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--------
Tellina (Miratellina) anazia Woodring, n. sp	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--------
Tellina (Eurytellina) punicea Born	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	R	--	--	--	--	--	F	--	--	--------	--	--	--	--------
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Tellina (Eurytellina) angulosa costaricana Olsson	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	--	--	--	--	--------	--	--	F	--------
Tellina sp [12]	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--------
Tellidora cristata (Réclus)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	--	--	--	--	--------	--	--	R	--------
Strigilla (Strigilla) carnaria (Linné)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	R	R	--	--	--------	--	--	--	--------
Psammacoma gatunensis (Toula)	--	--	--	--	F	--	--	R	R	F	F	--	--	--	--	--	--	--------	R	--	--	F	--	R	R	--	R	--	--------	--	--	--	--------
Psammotreta hadra Woodring, n. sp	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--------
Donax carinatus palaius Woodring, n. subsp	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--------
Sanguinolaria (Sanguinolaria) aff. *S. tellinoides* A. Adams	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--------
Solecurtus broggii gatunensis Toula	R	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	F	--	--	--	--	--	--	--	--	--	--------	--	--	R	--------
Tagelus (Mesopleura) divisus (Spengler)?	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--------
Semele cf. *S. perlamellosa* Heilprin	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--------
Semele laevis costaricensis Olsson	R	R	F	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--------	C	--	--	R	--	--	--	--	--	--	--------	--	--	--	--------
Semele sayi Toula	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	R
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Gouldia costaricensis (Olsson)	--	R	--	--	A	--	--	--	--	C	--	--	--	--	--	--	R	R	--	R	--	--	F	R	C	--	--	--	--------	--	--	C	--------
Tivela mactroides (Born), small form	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--------
Transennella cola Woodring, n. sp	--	F	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	--	--	--	--	--------	--	--	F	--------
Pitar (Hyphantosoma) centangulatus Brown and Pilsbry	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	R	--	--	--	--	--------	--	--	--	--------
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Hysteroconcha rosea vanwinkleae (Olsson)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	R	--	--	--	--	--	--	--------	--	--	--	--------
Lamelliconcha cora (Brown and Pilsbry)	F	F	F	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	R	--	--	--	--	--	--	--	--	F	--------	--	--	--	--------
Macrocallista (Paradione) maculata (Linné)	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--------	--	--	--	R	--	--	--	--	R	--	--------	R	--	--	--------
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Agriopoma (Pitarella) gatunensis (Dall)	R	C	F	C	F	--	--	--	F	R	F	--	--	R	--	R	R	--------	F	--	--	C	R	C	A	--	C	F	R	--	--	--	--------
Dosinia (Dosinia) delicatissima Brown and Pilsbry	R	--	--	--	--	--	--	--	--	R	--	--	--	--	R	--	--	--------	--	--	--	--	--	R	--	--	--	--	--------	R	--	R	--------
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Cyclinella cyclica (Guppy)	R	R	R	R	--	R	--	--	--	--	R	--	--	--	R	R	--	--------	F	--	--	R	--	--	--	--	--	F	--------	--	--	R	--------
Clementia (Clementia) dariena dariena (Conrad)	R	F	R	R	--	--	R	--	--	--	--	--	--	F	--	R	--	--------	C	C	--	C	--	--	R	--	--	R	--------	--	--	R	--------
Chione (Chionopsis) tegulum Brown and Pilsbry	C	C	F	R	--	--	--	--	--	--	R	--	R	--	--	--	--	--------	F	--	--	F	--	R	--	--	--	R	R	--	--	--	--------
Lirophora (Lirophora) falconensis (H. K. Hodson)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	--	--	--	--	--------	--	--	F	--------
Lirophora (Panchione) mactropsis (Conrad)	--	C	--	F	A	F	F	--	A	A	A	--	--	--	--	F	C	--------	C	C	--	C	C	A	A	--	C	C	--------	--	--	C	--------
Nioche (Antinioche) dolicha Woodring, n. sp	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--------
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Petricola millestriata Brown and Pilsbry	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	--	--	--	--	--	--	--	--------	--	--	--	R
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Caryocorbula oropendula stena Woodring, n. subsp	--	--	--	--	A	--	--	R	F	A	R	--	--	--	--	--	--	R	R	R	--	F	F	C	C	--	--	--	--------	--	--	C	--------
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See footnotes at end of table.

Pelecypods (Propeamussiidae to Cuspidariidae, Manzanellidae), a cephalopod (Nautilidae), and additional gastropods from Gatun formation—Continued

[R, rare; F, few; C, common; A, abundant]

	Localities—Continued																																
	Middle part—Continued																																
	Eastern area—Continued																																
	145	146	147	147a	147b	147c	147d	147e	147f	147g	147h	147i	147j	149	150	150a	151	152	153	153a	154	155	155a	155b	155c	156	157	158	159	159b	159c	159d	Other collections
Caryocorbula cf. *C. manzanillensis* (Maury)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Caryocorbula prenasuta Olsson	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--
Bothrocorbula (*Hexacorbula*) *gatunensis* (Toula)	--	--	R	--	--	--	--	--	--	--	--	--	--	--	R	--	R	--	--	--	--	C	--	R	F	--	--	R	--	--	--	--	--
Varicorbula disparilis (d'Orbigny), small form	--	A	--	--	A	--	--	--	A	A	A	--	--	--	--	--	R	--	--	C	--	--	R	--	F	--	--	R	--	--	--	C	--
Varicorbula islatrinitatis (Maury)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	C	--	--	--	--	--	--	R	--	C	--	--	--	--	--	--	--	--	--
Panopea parawhitfieldi (Gardner)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--
Martesia sanctipauli Maury	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--
Unidentifiable tubes of wood-boring teredinids	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	C	--	--	--	--	--	--	--	--	--	--	C	--	--	--
Kuphus "*incrassatus* Gabb"	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--
Pholadomya falconensis F. and H. Hodson	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pandora (*Pandorella*) *inconspicua* Gabb	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--
Cyathodonta? cf. *C.*? *dolicha* Woodring, n. sp	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--
Cyathodonta gatunensis (Toula)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--
Cuspidaria cf. *C. obesa* (Lovén)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cardiomya mansfieldi (Olsson and Harbison)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--
Nucinella cf. *N. woodii* (Dall)	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aturia curvilineata Miller and Thompson?	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

See footnotes at end of table.

Pelecypods (Propeamussiidae to Cuspidariidae, Manzanellidae), a cephalopod (Nautilidae), and additional gastropods from Gatun formation—Continued

[R, rare; F, few; C, common; A, abundant]

	Localities—Continued																																									
	Middle part—Continued																		Upper part																							
	Western area																		Eastern area																		Western area						
	160	160a	160d	161	161a	161b	161c	161d	162	162a	164	165	166	167	168	169	170	170a	163	171	172	173	173a	174	175	176	176a	177	177a	177b	177c	177d	177e	177f	178	180	181	182	182a	183	184	185
Cyclopecten oligolepis (Brown and Pilsbry)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--
Pecten (Oppenheimopecten) reliquus (Brown and Pilsbry)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pecten (Euvola) bowdenensis Dall	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	R	--
Flabellipecten gatunensis gatunensis (Toula)	--	C	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Flabellipecten gatunensis tapeinus Woodring, n. subsp	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
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Aequipecten plurinominis (Pilsbry and Johnson)	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Lepidopecten scissuratus (Dall)	--	--	R	--	R	--	--	--	--	--	--	--	--	--	--	?F	--	--	--	R	F	--	R	--	C	R	F	R	R	A	F	R	--	--	F	--	--	--	--	--	--	--
Leptopecten ecnomius Woodring, n. sp	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Argopecten levicostatus (Toula)	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	C	C	R	--	--
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Anomia peruviana gabbi Pilsbry and Johnson	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
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Crassostrea cahobasensis (Pilsbry and Brown)	--	--	--	--	--	--	--	--	--	--	--	--	--	C	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Ostrea equestris heothina Woodring, n. subsp	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	C	--	--	--	R	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	C
Lopha frons (Linné)	--	F	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
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Diplodonta (Diplodonta) homalostriata Woodring	--	--	--	R	--	--	--	--	--	R	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Diplodonta sp[1]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--
Diplodonta (Diplodonta) cf. *D. minor* Dall	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Timothynus capuloides (Gabb)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Temblornia virgata (Gardner)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
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Venericardia (Glyptoactis) aversa Pilsbry and Johnson	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pleuromeris aff. *P. acaris* (Dall)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Chama berjadinensis F. Hodson	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Arcinella arcinella (Linné), small form	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	C	--	--	--	R	--	R	--	--	--	C	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Arcinella arcinella (Linné)?	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	F	F	R	--	R
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Eucrassatella (Hybolophus) elassa Woodring, n. sp	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Eucrassatella (Hybolophus) venezuelana (F. Hodson)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--
Crassinella martinicensis (d'Orbigny)?	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Trachycardium (Trachycardium) cf. *T. isocardia* (Linné)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--
Trachycardium (Dallocardia) dominicense dominicense (Gabb)	C	--	--	R	R	--	--	--	--	--	--	R	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Trachycardium (Dallocardia) dominicense hadratatum Woodring, n. subsp	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	F	--	--	R
Trachycardium (Dallocardia) baiterum Woodring, n. sp	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Trachycardium (Phlogocardia) stiriatum (Brown and Pilsbry)	F	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	?R	--	--	--	--	--	--	R	--	--	--	--	--	--	--
Trachycardium (Mexicardia) dominicanum costaricanum (Olsson)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
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See footnotes at end of table.

Pelecypods (Propeamussiidae to Cuspidariidae, Manzanellidae), a cephalopod (Nautilidae), and additional gastropods from Gatun formation—Continued

[R, rare; F, few; C, common; A, abundant]

	Localities—Continued																																									
	Middle part—Continued																		Upper part																							
	Western area																		Eastern area																		Western area						
	160	160a	160d	161	161a	161b	161c	161d	162	162a	164	165	166	167	168	169	170	170a	163	171	172	173	173a	174	175	176	176a	177	177a	177b	177c	177d	177e	177f	178	180	181	182	182a	183	184	185
Trigoniocardia (Apiocardia) aminensis (Dall)	--	--	--	--	--	--	A	C	--	--	--	--	R	--	--	C	F	C	F	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	F
Lophocardium gurabicum (Maury)	F	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Dinocardium cf. *D. cabezai* (Gardner)	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
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Raeta undulata (Gould)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	F	--	--	--
Ervilia valhosierr Gardner	--	--	--	R	--	--	C	--	--	--	--	--	--	--	--	C	C	C	R	--	R	--	--	--	--	--	--	--	--	F	--	--	--	--	--	--	--	--	--	--	--	--
Solen (Solena) obliquus rudis C. B. Adams	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Tellina (Phyllodina) lepidota Dall	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	R	--	--	--	--	--	--	--	--	--	--	--
Tellina (Merisca) cristallina Spengler	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Tellina (Merisca) aequistriata Say	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Tellina (Miratellina) anaxia Woodring, n. sp	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Tellina (Eurytellina) punicea Born	C	--	--	--	--	--	--	R	--	R	--	--	--	--	--	R	--	--	--	--	R	--	R	--	R	R	--	R	R	F	--	R	--	--	--	--	--	--	--	--	--	--
Tellina (Eurytellina) nitens C. B. Adams	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Tellina (Eurytellina) angulosa costaricana Olsson	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Tellina sp [1] [2]	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	R	--	--	--	--	--	--	--	--	--	--	--	--	--	R
Tellidora cristata (Récluz)	--	--	--	R	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Strigilla (Strigilla) carnaria (Linné)	--	--	--	--	--	--	F	--	--	--	--	--	--	--	--	--	R	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Psammacoma gatunensis (Toula)	C	--	--	F	--	--	R	--	--	--	--	--	R	--	--	--	--	R	--	--	R	--	R	--	R	R	R	R	--	R	F	R	R	--	--	--	--	--	--	--	--	--
Psammotreta hadra Woodring, n. sp	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Donax carinatus palaius Woodring, n. subsp	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sanguinolaria (Sanguinolaria) aff. *S. tellinoides* A. Adams	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Solecurtus broggii gatunensis Toula	R	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--
Tagelus (Mesopleura) divisus (Spengler)?	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Semele cf. *S. perlamellosa* Heilprin	F	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Semele laevis costaricensis Olsson	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Semele sayi Toula	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Abra (Abra) lioica (Dall)?	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Alveinus rotundus Dall	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	A	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R
Ventricolaria sp	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Gouldia costaricensis (Olsson)	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	F	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	R	--	--	R	--	--	--	--	--	--	--
Tivela mactroides (Born), small form	--	--	--	--	--	--	R	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Transennella cola Woodring, n. sp	--	--	--	--	--	--	--	--	--	--	--	--	F	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pitar (Hyphantosoma) centangulatus Brown and Pilsbry	R	--	--	--	--	--	--	--	--	--	--	--	R	--	--	F	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Hysteroconcha sp	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Hysteroconcha rosea vanwinkleae (Olsson)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Lamelliconcha cora (Brown and Pilsbry)	R	--	--	F	--	--	R	--	--	--	--	--	--	--	--	--	--	F	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	R	--	--	--
Macrocallista (Paradione) maculata (Linné)	F	--	--	F	R	--	--	--	R	--	--	--	R	--	--	F	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	F	F	--	--	R
Costacallista leiotera Woodring, n. sp	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	C	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Agriopoma (Pitarella) gatunensis (Dall)	R	R	R	F	R	--	--	--	C	R	--	--	--	--	R	--	--	--	F	--	R	--	R	R	C	F	C	C	--	F	R	--	F	C	C	--	--	--	--	R	--	R
Dosinia (Dosinia) delicatissima Brown and Pilsbry	C	--	C	R	--	--	--	--	R	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	F	R	--	--	R
Dosinia (Dosinia) aff. *D. ponderosa titan* Maury	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--
Cyclinella cyclica (Guppy)	F	--	--	R	--	--	--	--	--	F	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Clementia (Clementia) dariena dariena (Conrad)	C	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Chione (Chionopsis) tegulum Brown and Pilsbry	F	--	--	R	--	--	C	--	R	--	--	--	--	--	--	--	--	F	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	F	F	--	--	--
Lirophora (Lirophora) falconensis (H. K. Hodson)	--	--	--	R	--	--	--	--	R	R	--	--	--	--	--	F	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--
Lirophora (Panchione) mactropsis (Conrad)	F	--	F	--	--	--	--	--	--	--	--	--	R	--	--	A	--	--	F	F	F	--	R	--	C	R	--	--	A	A	--	--	--	--	F	--	--	R	--	C	--	--
Nioche (Antinioche) dolicha Woodring, n. sp	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Parastarte psila Woodring, n. sp	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Petricola millestriata Brown and Pilsbry	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Rupellaria typica (Jonas)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R
Caryocorbula oropendula stena Woodring, n. subsp	--	--	--	R	F	R	--	R	--	--	--	--	R	--	--	F	--	--	--	--	R	R	C	--	--	--	--	--	--	--	R	R	--	--	--	--	--	--	--	--	--	--
Caryocorbula oropendula dolicha Woodring, n. subsp	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	A
Caryocorbula cf. *C. manzanillensis* (Maury)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	C	--	--	--	--	--	--	--	--	--	--	--	--
Caryocorbula prenasuta Olsson	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	C	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

See footnotes at end of table.

Pelecypods (Propeamussiidae to Cuspidariidae, Manzanellidae), a cephalopod (Nautilidae), and additional gastropods from Gatun formation—Continued

[R, rare; F, few; C, common; A, abundant]

	Localities—Continued																																									
	Middle part—Continued																		Upper part																							
	Western area																		Eastern area																		Western area						
	160	160a	160d	161	161a	161b	161c	161d	162	162a	164	165	166	167	168	169	170	170a	163	171	172	173	173a	174	175	176	176a	177	177a	177b	177c	177d	177e	177f	178	180	181	182	182a	183	184	185
Bothrocorbula (*Hexacorbula*) *gatunensis* (Toula)	--	--	--	F	--	--	--	--	--	--	--	--	--	--	C	C	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--
Varicorbula disparilis (d'Orbigny). small form	--	--	--	--	--	--	--	--	--	--	--	--	F	--	--	A	--	F	--	R	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	C
Varicorbula islatrinitatis (Maury)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Panopea parawhitfieldi (Gardner)	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Martesia sanctipauli Maury	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Unidentifiable tubes of wood-boring teredinids	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Kuphus "incrassatus Gabb"	R	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pholadomya falconensis F. and H. Hodson	F	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pandora (*Pandorella*) *inconspicua* Gabb	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cyathodonta? cf. *C.*? *dolicha* Woodring, n. sp	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cyathodonta gatunensis (Toula)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cuspidaria cf. *C. obesa* (Lovén)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	R	--	--	--	--	--	--	--	--	--	--
Cardiomya mansfieldi (Olsson and Harbison)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Nucinella cf. *N. woodii* (Dall)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aturia curvilineata Miller and Thompson?	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

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[1] Not described. [2] Immature or defective.

Mollusks from Gatun formation and occurrence elsewhere and in other Canal Zone formations of same or related forms—Continued

Species from Gatun formation	Occurrence elsewhere and in other Canal Zone formations of same, or related forms
Eucrassatella (*Hybolophus*) *elassa* Woodring, n. sp.	*E.* (*H.*) *berryi* (Spieker), lower part of Zorritos formation, early Miocene, Perú.
Eucrassatella (*Hybolophus*) *venezuelana* (F. Hodson).	Piojó and Tubará formations, middle Miocene, Atlántico Dept., Colombia; Caujarao and Cantaure formations, middle Miocene, Falcón, Venezuela; Usiacurí formation, late Miocene, Atlántico Dept. Colombia; El Veral formation, late Miocene, Falcón, Venezuela.
Crassinella martinicensis (d'Orbigny)?.	*C. martinicensis* (d'Orbigny), Holocene, Caribbean region.
Trachycardium (*Dallocardia*) *dominicense dominicense* (Gabb).	Deposits of early Miocene age at Sapote [Zapate], northeastern Costa Rica (Gabb's record); Miocene, Dominican Republic; deposits of middle Miocene age, Limón Province, Costa Rica; Miocene, Atlántico Dept., Colombia (Anderson's record); Angostura formation, middle Miocene, Ecuador.
Trachycardium (*Dallocardia*) *dominicense hadratatum* Woodring, n. subsp.	*T.* (*D.*) *dominicense dominicense* (Gabb).
Trachycardium (*Dallocardia*) *baiterum* Woodring, n. sp.	*T.* (*D.*) *puebloense* (Anderson), Tubará formation, middle Miocene, Atlántico Dept., Colombia.
Trachycardium (*Phlogocardia*) *stiriatum* (Brown and Pilsbry).	*T.* (*P.*) *belcheri* (Broderip and Sowerby), Holocene, eastern Pacific Ocean.
Trachycardium (*Mexicardia*) *dominicanum costaricanum* (Olsson).	Deposits of middle Miocene age, Limón Province, Costa Rica.
Trigoniocardia (*Apiocardia*) *aminensis* (Dall).	Gurabo formation, middle Miocene, Dominican Republic; Toro limestone member of Chagres sandstone, late Miocene or early Pliocene.
Lophocardium gurabicum (Maury).	Gurabo formation, middle Miocene, Dominican Republic; deposits of middle Miocene age, Limón Province, Costa Rica (Olsson's record); Limónes formation, Limón Province, Costa Rica (Olsson's record); deposits of late middle Miocene age, western Florida.
Dinocardium cf. *D. cabezai* (Gardner).	*D. cabezai* (Gardner). Shoal River formation, middle Miocene, Florida.
Laevicardium laevigatum (Linné).	Late Oligocene to Holocene, western Atlantic Ocean.
Mactrellana alata (Spengler)	Deposits of middle Miocene age, Limón Province, Costa Rica, Jama and Canoa formations, Pliocene, Ecuador; Holocene, western Atlantic and eastern Pacific Oceans.

Mollusks from Gatun formation and occurrence elsewhere and in other Canal Zone formations of same or related forms—Continued

Species from Gatun formation	Occurrence elsewhere and in other Canal Zone formations of same, or related forms
Mulinia aff. *M. lateralis* (Say).	*M. lateralis* (Say). Miocene to Holocene, western Atlantic Ocean.
Mulinia aff. *M. cleryana* (d'Orbigny).	Tubará formation, middle Miocene, Atlántico Dept., Colombia; Usiacurí formation, late Miocene, Atlántico Dept., Colombia.
Harvella elegans elegans (Sowerby).	Deposits of middle Miocene age, Limón Province, Costa Rica; middle Miocene deposits, Río Sinú area, Cordoba Dept., Colombia; Tubará formation, middle Miocene, Atlántico Dept., Colombia; middle Miocene deposits, Trinidad (Maury's record); Usiacurí formation, late Miocene, Atlántico Dept., Colombia; Borbon formation, late Miocene. Ecuador; Las Sierras formation, early Pliocene, Nicaragua; Holocene, Gulf of California to northern Perú.
Raeta hasletti (Anderson)	Tubará formation, middle Miocene, Atlántico Dept., Colombia.
Raeta undulata (Gould)	Progreso formation, middle Miocene, Ecuador; Olsson's "Pinecrest beds," late Miocene, Florida; El Veral formation, late Miocene, Falcón, Venezuela; Urumaco formation, middle or late Miocene, Falcón, Venezuela; Borbon formation, late Miocene. Ecuador; Tumbes formation, late Miocene, Perú; Jama formation, Pliocene. Ecuador; Holocene, southern California to northern Perú.
Ervilia valhosierr Gardner	Shoal River formation, middle Miocene, Florida.
Solen (*Solena*) *obliquus rudis* C. B. Adams.	Holocene, Costa Rica to Perú.
Tellina (*Phyllodina*) *lepidota* Dall.	Limónes formation, late Miocene, Bocas del Toro area, Panamá.
Tellina (*Merisca*) *cristallina* Spengler.	Deposits of middle Miocene age, Limón Province, Costa Rica; Cercado formation, middle Miocene, Dominican Republic; Mare formation, early Pliocene, Venezuela; Holocene, South Carolina to Virgin Islands, Panamá to Ecuador.
Tellina (*Merisca*) *aequistriata* Say.	Chipola formation, early Miocene, Florida; Bowden formation, middle Miocene, Jamaica; Yorktown formation, early Pliocene, Virginia; Chagres sandstone, late Miocene or early Pliocene, identification doubtful; formations

Mollusks from Gatun formation and occurrence elsewhere and in other Canal Zone formations of same or related forms—Continued

Species from Gatun formation	Occurrence elsewhere and in other Canal Zone formations of same, or related forms
	of middle Miocene to Pliocene age, southeastern United States; Holocene, southern Florida to Bahia, Brasil.
Tellina (*Miratellina*) *anaxia* Woodring, n. sp.	*T.* (*M.*) *aequizonta* Pilsbry and Olsson, Jama formation, Pliocene, Ecuador.
Tellina (*Eurytellina*) *punicea* Born.	Moderately deep-water facies of Caimito formation, late Oligocene; deposits of Oligocene(?) age on Oronli Creek, Limón Province, Costa Rica (Gabb's record); Miocene deposits, Colombia (Anderson's record); Limónes formation, late Miocene, Bocas del Toro area, Panamá (Olsson's record): Mare formation, early Pliocene, Venezuela; Courbaril member of Morne l'Enfer formation, Pliocene, Trinidad; Holocene, Belize and Jamaica to Santa Catarina, Brasil.
Tellina (*Eurytellina*) *nitens* C. B. Adams.	Oak Grove sand member of Shoal River formation, middle Miocene, Florida; Holocene, North Carolina to Rio de Janeiro, Brasil.
Tellina (*Eurytellina*) *angulosa costaricana* Olsson.	Deposits of middle Miocene age, Limón Province, Costa Rica.
Tellidora cristata (Récluz)	Deposits of middle Miocene age, Limón Province, Costa Rica; Melajo clay member of Springvale formation, late Miocene, Trinidad; deposits of late Miocene age, western Florida; Caloosahatchee formation, Pliocene, Florida; Holocene, North Carolina to Yucatan.
Strigilla (*Strigilla*) *carnaria* (Linné).	Courbaril member of Morne l'Enfer formation and Matura formation, Pliocene, Trinidad; Holocene, Florida and Bahamas to Mar del Plata, Argentina.
Psammacoma gatunensis (Toula).	Deposits of middle Miocene age, Limón Province, Costa Rica, Darién Province, Panamá, Bolívar Dept. Colombia; Urumaco formation, middle or late Miocene, Falcón, Venezuela.
Psammotreta hadra Woodring.	*P. grandis* (Hanley). Holocene, eastern Pacific Ocean.
Donax carinatus palaius Woodring, n. subsp.	*D. carinatus carinatus* Hanley, Holocene, Sinaloa, México, to northern Perú.
Sanguinolaria (*Sanguinolaria*) aff. *S. tellinoides* A. Adams.	*S.* (*S.*) *tellinoides* A. Adams, Jama formation, Pliocene, Ecuador; Holocene, Gulf of California to Ecuador.

Mollusks from Gatun formation and occurrence elsewhere and in other Canal Zone formations of same or related forms—Continued

Species from Gatun formation	Occurrence elsewhere and in other Canal Zone formations of same, or related forms
Solecurtus broggii gatunensis Toula.	Deposits of middle Miocene age, Limón Province, Costa Rica.
Tagelus (*Mesopleura*) *divisus* (Spengler)?.	*T.* (*M.*) *divisus* Spengler, late Miocene to Holocene, western Atlantic Ocean.
Semele cf. *S. perlamellosa* Heilprin.	Toro limestone member of Chagres sandstone, late Miocene or early Pliocene.
Semele laevis costaricensis Olsson.	Deposits of middle Miocene age, Limón Province, Costa Rica; Tubará formation, middle Miocene, Atlántico Dept., Colombia; Angostura formation, middle Miocene, Ecuador; upper part of Zorritos formation, middle Miocene, Perú; Urumaco formation middle or late Miocene, Falcón, Venezuela; Gansul clay and Melajo clay members of Springvale formation, late Miocene, Trinidad; Courbaril member of Morne l'Enfer formation, Pliocene, Trinidad.
Semele sayi Toula	Deposits of middle Miocene age, Limón Province, Costa Rica (Olsson's record).
Abra (*Abra*) *lioica* (Dall)?	*A.* (*A.*) *lioica* (Dall), Holocene, North Carolina to Santa Caterina, Brasil.
Alveinus rotundus Dall	Chipola formation, early Miocene, Florida; Shoal River formation, middle Miocene, Florida; Angostura formation, middle Miocene, Ecuador.
Gouldia costaricensis (Olsson).	Deposits of middle Miocene age, Limón province, Costa Rica; Shoal River formation, middle Miocene, Florida.
Tivela mactroides (Born), small form.	*See* Culebra formation.
Transennella cola Woodring, n. sp.	*T. caboblanquensis* Weisbord, Mare formation, early Pliocene, Venezuela.
Pitar (*Hyphantosoma*) *centangulatus* Brown and Pilsbry.	*P.* (*H.*) *carbaseus* (Guppy), Bowden formation, middle Miocene, Jamaica.
Hysteroconcha rosea vanwinkleae (Olsson).	Deposits of middle Miocene age, Limón Province, Costa Rica; late Miocene deposits, Falcón, Venezuela.
Lamelliconcha cora (Brown and Pilsbry).	Subibaja formation, early Miocene, Ecuador; Progreso and Angostura formations, middle Miocene, Ecuador.
Macrocallista (*Paradione*) *maculata* (Linné).	Early Miocene to Holocene, Caribbean region.
Agriopoma (*Pitarella*) *gatunensis* (Dall).	Deposits of middle Miocene age, Limón Province, Costa Rica, Darién Province Panamá; Tubará formation, middle Miocene, Atlántico Dept., Colombia

Mollusks from Gatun formation and occurrence elsewhere and in other Canal Zone formations of same or related forms—Continued

Species from Gatun formation	Occurrence elsewhere and in other Canal Zone formations of same, or related forms
	(Anderson's record); Machapoorie limestone member and Brasso formation proper, Trinidad (Maury's record); Daule formation, middle Miocene, Ecuador (Mark's record). Limónes formation, late Miocene, Bocas del Toro area, Panamá.
Dosinia (*Dosinia*) *delicatissima* Brown and Pilsbry.	*See* La Boca formation.
Dosinia (*Dosinia*) aff. *D. ponderosa titan* Maury.	*See* upper member of Alhajuela formation.
Cyclinella cyclica (Guppy)	Deposits of middle Miocene age, Darién Province, Panamá (Palmer's record); Miocene, presumably middle, Dominican Republic (Gabb's record); Tubará formation, middle Miocene, Atlántico Dept., Colombia; Cantaure formation, middle Miocene, Falcón, Venezuela; San Jose calcareous silt member of Manzanilla formation, middle Miocene, Trinidad; Urumaco formation, middle or late Miocene, Falcón, Venezuela; El Veral formation, late Miocene, Falcón, Venezuela.
Clementia (*Clementia*) *dariena dariena* (Conrad).	Early Miocene to late Miocene; early Miocene: La Boca formation; formations in northeastern Costa Rica, southwestern Costa Rica, Colombia, Ecuador, and Perú; middle Miocene: formations in Darién, Colombia, Venezuela, Trinidad, Nicaragua, Ecuador, and Perú; late Miocene: formations in Bocas del Toro area, Panamá, Venezuela, and Trinidad.
Chione (*Chionopsis*) *tegulum* Brown and Pilsbry.	Deposits of middle Miocene age, Limón Province, Costa Rica (Olsson's record); Cantaure formation, middle Miocene, Falcón, Venezuela.
Lirophora (*Lirophora*) *falconensis* (H. K. Hodson).	*See* lower member of Alhajuela formation.
Lirophora (*Panchione*) *mactropsis* (Conrad).	Early Miocene to Pliocene in Tertiary Caribbean province; early Miocene: formation in southwestern Costa Rica (locality needs confirmation); middle Miocene: formations in Oaxaca, México, Veracruz, México, Limón Province, Costa Rica, Darién, Sinú area, Colombia, Atlántico Dept., Colombia; Chiriquí Province, Panamá, Falcón, Venezuela, Ecuador; late Miocene: Tehuantepec area, México, Bocas del Toro area, Panamá. Pliocene: Charco Azul formation of Terry (1941), Panamá.
Nioche (*Antinioche*) *dolicha* Woodring, n. sp.	*N.* (*A.*) *beili* Olsson. Holocene, eastern Pacific Ocean.
Rupellaria typica (Jonas)	Holocene, western Atlantic and eastern Pacific Oceans.
Caryocorbula oropendula stena Woodring, n. subsp.	*C. oropendula oropendula* (Olsson), middle Miocene, Limón Province, Costa Rica.
Caryocorbula oropendula dolicha Woodring, n. subsp.	*C. oropendula oropendula* (Olsson), middle Miocene, Limón Province, Costa Rica.
Caryocorbula cf. *C. manzanillensis* (Maury).	*C. manzanillensis* (Maury) San Jose calcareous silt member of Manzanilla formation, middle Miocene, Trinidad.
Caryocorbula prenasuta Olsson.	Angostura formation, middle Miocene, Ecuador.
Bothrocorbula (*Hexacorbula*) *gatunensis* (Toula).	Middle Miocene deposits: Río Sinú area, Córdoba Dept., Colombia; Jesus del Monte-Zambrano area, Bolívar Dept., Colombia; Tubará formation, Atlántico Dept., Colombia; Choco Dept., Colombia; Angostura formation, Ecuador; late Miocene deposits: Limónes formation, Bocas del Toro area, Panamá; presumably La Vela formation, Falcón, Venezuela.
Varicorbula disparilis (d'Orbigny), small form.	Deposits of middle Miocene age, Limón Province, Costa Rica; Darién Province, Panamá; Shoal River formation proper and Oak Grove sand member, middle Miocene, Florida; Limónes formation, late Miocene, Limón Province, Costa Rica, Bocas del Toro area, Panamá. Moín formation, late Pliocene, Limón Province, Costa Rica; Pliocene deposits, Bocas del Toro area, Panamá.
Varicorbula islatrinitatis (Maury).	Savaneta glauconitic sandstone member and Melajo clay member of Springvale formation, late Miocene, Trinidad; presumably La Vela formation, late Miocene, Falcón, Venezuela.
Panopea parawhitfieldi (Gardner).	*See* upper member of Alhajuela formation.
Martesia sanctipauli Maury	Cercado formation, middle Miocene, Dominican Republic.

Mollusks from Gatun formation and occurrence elsewhere and in other Canal Zone formations of same or related forms—Continued

Species from Gatun formation	Occurrence elsewhere and in other Canal Zone formations of same, or related forms
Kuphus "incrassatus Gabb"	*See* Culebra formation.
Pholadomya falconensis F. and H. Hodson.	Presumably La Vela formation, late Miocene, Falcón, Venezuela.
Pandora (Pandorella) inconspicua Gabb.	Cercado formation, middle Miocene, Dominican Republic.
Cyathodonta? cf. *C.*? *dolicha* Woodring, n. sp.	*C.*? *dolicha* Woodring, n. sp., Bohio formation, late Oligocene.
Cyathodonta gatunensis (Toula).	Toro limestone member of Chagres sandstone, late Miocene or early Pliocene.
Cuspidaria cf. *C. obesa* (Lovén).	*C. obesa* Lovén, Holocene, western Atlantic Ocean.
Cardiomya mansfieldi (Olsson and Harbison).	Deposits of late Miocene age, western Florida. Caloosahatchee formation, Pliocene, Florida.
Nucinella cf. *N. woodii* (Dall).	*N. woodii* (Dall), late Miocene, western Florida; Caloosahatchee formation, Pliocene, Florida.
Aturia curvilineata Miller and Thompson?	*A. curvilineata* Miller and Thompson, Cantaure formation, middle Miocene, Falcón, Venezuela.

Pycnodonte, *Miratellina* (subgenus of *Tellina*), and *Aturia* are extinct.

The genera and subgenera in the following table are paciphile taxa; that is, they formerly lived in western Atlantic waters but are now extinct there, though they survive in eastern Pacific waters.

Paciphile genera and subgenera covered in present chapter

[E, early; M, middle; L, late]

Genus or subgenus	Formation	Western Atlantic waters										
		Eocene			Oligocene		Miocene			Late Miocene or early Pliocene	Plio-cene
		E	M	L	E	L	E	M	L		
Flabellipecten	Caimito through Chagres, except Culebra					—	—	—	—	—	
Myobolophus, subgenus of *Eucrassatella*, elongate species	Gatun							—	—		
Phlogocardia, subgenus of *Trachycardium*	Gatun							—	—		
Mexicardia, subgenus of *Trachycardium*	Gatun							—			
Nemocardium	La Boca	—	—	—	—	—	—				
Harvella	La Boca, Gatun						—	—	—		
Pitarella, subgenus of *Agriopoma*	Gatun							—	—		
Clementia, subgenus of *Clementia*	Culebra, La Boca, Gatun					—	—	—	—		
Panchione, subgenus of *Lirophora*	La Boca, upper member of Alhajuela, Gatun						—	—	—		
Antinioche, subgenus of *Nioche*	Gatun							—			
Hexacorbula, subgenus of *Bothrocorbula*	Culebra, La Boca, Gatun						—	—	—		

Genus or subgenus	Formation	Eastern Pacific waters										
		Eocene			Oligocene		Miocene			Late Miocene or early Pliocene	Plio-cene
		E	M	L	E	L	E	M	L		
Flabellipecten	Caimito through Chagres, except Culebra						—	—			—
Myobolophus, subgenus of *Eucrassatella*, elongate species	Gatun						—	—			
Phlogocardia, subgenus of *Trachycardium*	Gatun									—	
Mexicardia, subgenus of *Trachycardium*	Gatun										—
Nemocardium	La Boca	—	—		—						
Harvella	La Boca, Gatun								—		—
Pitarella, subgenus of *Agriopoma*	Gatun							—			
Clementia, subgenus of *Clementia*	Culebra, La Boca, Gatun	—	—	—	—	—	—	—	—		
Panchione, subgenus of *Lirophora*	La Boca, upper member of Alhajuela, Gatun							—	—		—
Antinioche, subgenus of *Nioche*	Gatun										
Hexacorbula, subgenus of *Bothrocorbula*	Culebra, La Boca, Gatun							—	—		

A total of 41 genera or subgenera in the faunas under study are now recognized as paciphile taxa.

The following three subspecies are paciphile taxa at the species level:

Donax carinatus palaius Woodring n. subsp., Gatun formation.
Solecturtus broggii gatunensis Toula, Gatun formation; a related form in La Boca formation.
Semele laevis costaricensis Olsson, Gatun formation, elsewhere middle Miocene to Pliocene.

The following Canal Zone species are more closely related to living eastern Pacific species than to living western Atlantic species:

Canal Zone species more closely related to living eastern Pacific species than to living western Atlantic species

Canal Zone species	Living eastern Pacific species
Pecten (Oppenheimopecten) colpotus Woodring n. sp., lower member of Alhajuela formation.	*P. (O.) vogdesi* Arnold.
Nodipecten denaius Woodring, n. sp., La Boca formation; Caimito formation and Emperador limestone member of La Boca formation doubtful.	*N. magnificus* (Sowerby).
Nodipecten clydonus Woodring, n. sp., lower member of Alhajuela formation.	*N. magnificus* (Sowerby).
Psammacoma gatunensis (Toula), Gatun formation.	*P. lamproleuca* (Pilsbry and Lowe).
Psammotreta hadra Woodring, n. sp., Gatun formation.	*P. grandis* (Hanley).
Florimetis trinitaria (Dall), lower member of Alhajuela formation.	*F. cognata* (Pilsbry and Vanatta).
Donax aff. *D. asper* Hanley, La Boca formation.	*D. asper* Hanley.
Gari (Gobraeus) listrota listrota Woodring, n. sp. and subsp., marine rocks of late Eocene age.	*G. (G.) panamensis* Olsson.
Gari (Gobraeus) listrota hadratera Woodring, n. subsp., Bohio formation.	*G. (G.) panamensis* Olsson.
Sanguinolaria (Sanguinolaria) aff. *S. (S.) tellinoides* Adams, Gatun formation.	*S. (S.) tellinoides* A. Adams.
Dosinia (Dosinia) aff. *D. ponderosa titan* Maury, upper member of Alhajuela formation; Gatun formation.	*D. (D.) ponderosa* (Gray).

The following survive in the eastern Pacific Ocean:

Anomia peruviana gabbi Pilsbry and Johnson (the species, but not the subspecies), lower member of Alhajuela formation, Gatun formation.
Harvella elegans elegans (Sowerby), Gatun formation.
Raeta undulata (Gould), Gatun formation.
Solen (Solena) obliquus rudis C. B. Adams. Gatun formation.

Mactrellona alata (Spengler) and *Tellina (Merisca) cristallina* Spengler survive in both oceans. Both occur in the Gatun formation.

As discussed in earlier chapters, few caribphile taxa (taxa that formerly lived in eastern Pacific waters but that now are extinct there and survive in western Atlantic waters) are rare. The following caribphile genera and subgenera are covered in present chapter:

Genus or subgenus	Occurrence in eastern Pacific waters
Euvola, subgenus of *Pecten*	*P. (E.) keepi* Arnold, Imperial formation of Colorado Desert, California.
Phacoides	Early(?) Miocene in Ecuador.
Dinocardium	Middle Miocene, Angostura formation, Ecuador.

An unnamed subspecies of *Polinices brunneus* (Link), a living Caribbean species, is recorded from the late Miocene or early Pliocene Esmeraldas formation of Ecuador (Olsson, 1964, p. 179, pl. 32, figs. 6, 6a), but only one specimen is available.

MIOCENE OR PLIOCENE SERIES

CHAGRES SANDSTONE

The eight species and subspecies from the Chagres sandstone proper, from a total of 47, are listed in the following table. The type of *Flabellipecten gatunensis tapeinus* is from the Chagres. That subspecies occurs also in the middle part of the Gatun formation. The type of *Amusium mimyum*, an umbonally ribbed species, is also from the Chagres. *Cryptopecten cactaceus* is an interesting species, the type of which is from the Tehuantepec area of México. *Lucinoma tapeina* is a small species of a basically northern genus.

The species or related species that occur elsewhere and in other Canal Zone formations are tabulated as follows:

Species from Chagres sandstone proper and occurrence elsewhere and in other Canal Zone formations of same or related species

Species from Chagres sandstone proper	Occurrence elsewhere and in other Canal Zone formations of same or related species
Flabellipecten gatunensis tapeinus Woodring, n. subsp.	Gatun formation, middle Miocene.
Amusium mimyum Woodring, n. sp.	Deposits of late Miocene age, Tehuantepec area, Vera Cruz, México.
Cryptopecten cactaceus (Dall).	Spencer's Coatzacoalcos formation, Tehuantepec area, Vera Cruz, México.
Argopecten nerterus Woodring, n. sp.	Toro limestone member of Chagres sandstone, late Miocene or early Pliocene.
Lucinoma tapeina Woodring, n. sp.	*L. chiripanica* Olsson, Charco Azul formation of Terry (1941), Panama-Costa Rica border, Pliocene; Esmeraldas formation, Ecuador, Miocene or Pliocene.
Tellina (Tellinella) cf. *T. rovala* Olsson.	*T. (T.) rovala* Olsson, Limónes formation, Bocas del Toro area, Panamá, late Miocene.
Tellina (Merisca) aequistriata Say?.	*T. (M.) aequistriata* Say, Gatun formation, middle Miocene; elsewhere early Miocene to Holocene.
Tellina (Angulus) cf. *T. (A.) umbra* Dall.	*T. (A.) umbra* Dall, Deposits of middle Miocene age, Limón Province, Costa Rica; Duplin formation (of former usage), North Carolina, Pliocene.

TORO LIMESTONE MEMBER

The Toro limestone member lies at the base of the Chagres sandstone. It is the only high-energy, noncoralliferous, or sparingly coralliferous, limestone in the entire succession of fossiliferous formations. At many localities, barnacle fragments are more abundant than mollusks.

Pelecypods (Pectinidae to Veneridae) from Chagres sandstone proper

[R, rare; F, few; C, common; A, abundant]

	Localities										
	197	199	200	201	202	204	206	206a	206b	207	208
Flabellipecten gatunensis tapeinus Woodring, n. subsp	----	R	----	----	----	----	----	----	----	R	----
Amusium mimyum Woodring, n. sp	----	A	----	A	R	----	C	----	----	----	R
Chlamys? sp [1]	----	----	R	----	----	----	----	----	----	----	----
Cryptopecten cactaceus (Dall)	----	----	----	----	----	----	A	F	C	----	C
Argopecten nerterus Woodring, n. sp	----	----	----	R	?R	----	----	----	----	----	----
Lucinoma tapeina Woodring, n. sp	R	----	R	----	----	C	----	----	----	----	----
Arcinella sp [1]	----	----	----	R	----	----	----	----	----	----	----
Mactrid? [1]	----	----	----	----	R	----	----	----	----	----	----
Tellina (Tellinella) cf. *T. rovala* Olsson	----	----	----	R	----	----	----	----	----	----	----
Tellina (Merisca) aequistriata Say?	----	----	R	----	----	----	----	----	----	----	----
Tellina (Angulus) cf. *T. (A.) umbra* Dall	----	----	----	----	----	----	F	----	F	----	----
Psammacoma sp [1]	R	----	----	----	----	----	----	----	----	----	----
Pitar (Pitar) sp [1]	R	----	----	----	----	----	----	----	----	----	----

[1] Not described.

Pelecypods (Pectinidae to Thraciidae) from Toro limestone member of Chagres sandstone

[R, rare; F, few; C, common; A, abundant]

	Localities														
	187	188	188a	188b	188c	188d	188e	189	190	191	192	193	194	195	196
Flabellipecten gatunensis macdonaldi (Olsson)	?R	F	----	----	R	C	R	----	----	----	----	----	----	----	----
Amusium toulae (Brown and Pilsbry)	----	----	----	----	----	----	----	----	----	----	----	----	----	sp. R	F
Argopecten levicostatus (Toula)?	----	----	----	----	----	----	----	----	----	----	R	----	R	----	----
Argopecten nerterus Woodring, n. sp	F	A	C	R	R	A	F	----	----	----	----	----	----	----	----
Plicatula gibbosa Lamarck, small form	----	----	----	----	----	----	----	----	----	----	----	----	----	----	A
Anomia simplex d'Orbigny	----	----	----	----	----	----	----	----	F	C	R	F	F	C	F
Hyotissa haitensis (Sowerby)	----	----	----	----	----	----	----	F	----	----	----	----	----	----	----
Venericardia sp [1]	----	----	----	----	----	----	----	----	----	----	----	----	----	----	F
Arcinella sp [1]	----	----	----	----	----	----	----	----	----	----	----	----	----	----	F
Trachycardium (Trachycardium) cf. *T. isocardia* (Linné)	----	----	----	----	----	----	----	----	----	----	----	----	----	----	R
Trigoniocardia (Apiocardia) aminensis (Dall)	----	----	----	----	----	----	----	----	----	----	----	----	----	----	F
Tellina (Tellinella) sp [1]	----	----	----	----	----	----	----	----	----	----	----	----	----	R	----
Psammacoma sp [1]	----	----	----	----	----	----	----	----	----	----	----	----	----	----	R
Semele cf. *S. perlamellosa* Heilprin	----	----	----	----	----	----	----	----	----	----	----	----	----	----	R
Macrocallista (Paradione) maculata (Linné)	----	----	----	----	----	----	----	----	----	----	----	R	----	----	R
Dosinia sp [1]	----	----	----	----	----	----	----	----	----	----	----	R	----	R	----
Chione sp [1]	----	----	----	----	----	----	----	----	----	----	----	----	----	----	F
Cyathodonta gatunensis (Toula)	----	----	----	----	----	----	----	----	----	----	----	----	----	R	----

[1] Not described.

No study has been made of the mineralogy and source areas of the sandstones that constitute most of the fossiliferous formations. Toula described the sandstones of the Gatun formation as glauconitic. A casual inspection, however, shows that the greenish grains of the Gatun and other formations are from volcanic rocks.

The 11 species and subspecies of mollusks (of a total of 13) from the Toro described in the present chapter are listed in the following table. *Flabellipecten gatunensis macdonaldi* is a large subspecies of *F. gatunensis* group. *Hyotissa haitensis* is a conspicuous species.

The species or related species that occur elsewhere and in other Canal Zone formations are as follows:

Species from Toro limestone member of Chagres sandstone and occurrence elsewhere and in other Canal Zone formations of same, or related species

Species from Toro limestone member of Chagres sandstone	Occurrence elsewhere and in other Canal Zone formations of same, or related species
Flabellipecten gatunensis macdonaldi (Olsson).	Deposits of late middle Miocene age, western Florida.
Amusium toulae (Brown and Pilsbry).	*See* La Boca formation.
Argopecten levicostatus (Toula)?.	*A. levicostatus* (Toula), *see* Gatun formation.
Argopecten nerterus Woodring, n. sp.	Chagres sandstone proper, late Miocene or early Pliocene.
Plicatula gibbosa Lamarck, small form.	*P. gibbosa* Lamarck, middle Miocene to Holocene.
Anomia simplex d'Orbigny	Late early Miocene to Holocene, Caribbean region.
Hyotissa haitensis (Sowerby)	*See* La Boca formation.
Trigoniocardia (*Apiocardia*) *aminensis* (Dall).	*See* Gatun formation.
Semele cf. *S. perlamellosa* Heilprin.	Gatun formation, middle Miocene.
Macrocallista (*Paradione*) *maculata* (Linné).	Early Miocene to Holocene, Caribbean region.
Cyathodonta gatunensis (Toula).	Gatun formation, middle Miocene.

LINEAGES

Well-defined lineages are rare, especially lineages of considerable duration. The best example is the lineage of *Trachycardium* (*Dallocardia*) *dominicense*. It starts as a small form in the La Boca formation and the upper member of the Alhajuela formation, is succeeded in the middle part of the Gatun formation by the larger *T.* (*D.*) *dominicense dominicense*, and culminates in the upper part of the Gatun in the very large *T.* (*D.*) *dominicense hadratatum*. To be sure, the very large form was found in the western area, and the relations of the strata there to other parts of the Gatun are unknown.

Psammacoma diphas (Culebra and La Boca formations), *P. gatunensis* (Gatun formation), and *P. lamproleuca* (living, eastern Pacific Ocean) form a lineage graded in increasing size with decreasing age.

Solecurtus aff. *S. broggii gatunensis* (La Boca formation), *S. broggii gatunensis* (Gatun formation), and *S. broggii broggii* (Pliocene, Ecuador) are graded in increasing size with decreasing age, but the grading is not continued with living specimens of *S. broggii broggii*.

AGE ASSIGNMENTS AND CORRELATIONS

The only difference in age assignments from those adopted in P 306–E is that the Chagres sandstone is now designated as late Miocene or early Pliocene. That is the age designation adopted by Olsson (1964) for the Esmeraldas formation of Ecuador, with which the Chagres is correlated.

The Gatun formation is correlated with the Angostura formation of Ecuador. *Calloarca cachla* and *Lucina* (*Lepilucina*) *gratis* have been found so far only in the Gatun and Angostura formations, both of which are assigned to the middle Miocene.

In July 1977, Mr. Patrick Nuttall, of the British Museum (Natural History), wrote to inquire whether I had any samples of Foraminifera from the Gatun formation. Though I had no samples that were collected specifically for Foraminifera, I had some residues that looked promising. Three residues, one from the middle part of the formation and two from the upper part, were forwarded to him. They were examined by Dr. J. E. Whittaker and Mr. R. L. Hodgkinson, of the Protozoa Section of the British Museum (Natural History), whose report Mr. Nuttall kindly sent to me. These specialists had a sample from the lower part of the Gatun extracted from a British Museum (Natural History) specimen of *Cymatophos veatchi*, collected at locality 138 (USGS 16909). They reported an age of midzone N16 of Blow's zonation, early late Miocene = early Tortonian, or younger. The most satisfactory residue was from the middle part of the formation at locality 146 (USGS 5845). It gave a probable age of N17 and certainly not younger than N18 (earliest Pliocene). The residue from the upper part of the formation at locality 175 contains mostly juvenile planktonic Foraminifera. The age is not diagnostic but probably is latest Miocene or even early Pliocene. The residue from locality 177c (USGS 5855), also from the upper part of the formation, likewise contains mostly juvenile planktonic Foraminifera. It is dated as no younger than N18. This brief summary has been approved by Mr. Nuttall and is published with his permission.

It is not surprising that the Gatun is late Miocene or early Pliocene in terms of Blow's planktonic zonation. Throughout the Tertiary Caribbean province, age assignments based on planktonic and molluscan (basically Lyellian) data are in disagreement for middle and late Neogene formations. Pending resolution of this disagreement, molluscan ages are retained. Middle Miocene is retained, for example, for the Gatun and correlated formations—the Cercado and Gurabo formations of the Dominican Republic, which are faunal zones in a single formation, and the "shell bed" in the Bowden formation of Jamaica, Zone 16 of Blow's zonation (Blow, 1969), early late Miocene = early Tortonian. The most satisfactory residue was from the middle part of the Gatun at locality 146 (USGS 5845). It gave a probable age of N17 and certainly not younger than N18 (earliest Pliocene).

DESCRIPTION OF TERTIARY MOLLUSKS—CONTINUED FROM P 306–E

PELECYPODS—CONTINUED FROM P 306–E

Family PROPEAMUSSIIDAE

On the basis of gill structure, Ridewood (1903, p. 186, 207) proposed a family Amussiidae. He was dealing, however, with species of *Propeamussium*, which he assigned to *Amussium*. Abbott (1954, p. 361, 369) was aware of this and introduced the family name Propeamussiidae. The shell microstructure and some of the anatomical features of propeamussiids were described recently by Waller (1971, 1972).

Genus Cyclopecten Verrill

Verrill, Connecticut Acad. Arts and Sci. Trans., v. 10, p. 70, 1897.

Type (Logotype, Sykes, Smith, and Crick, Zoological Record, v. 34 (1897), Mollusca, p. 75, 1898): *Pecten pustulosus* Verrill, living Newfoundland to Virginia.

The left valve of the type species is strongly sculptured.

Cyclopecten species a

Plate 96, figure 6

A poorly preserved, relatively large right valve of *Cyclopecten* from the La Boca formation shows no disk sculpture. The auricles are exceptionally wide dorsoventrally. The anterior auricle is slightly longer than the posterior and is faintly sculptured radially.

Length (almost complete) 13.7 mm, height (practically complete) 13.7 mm (figured specimen).

The affinities of this species are undetermined.

Occurrence: La Boca formation (early Miocene), Gaillard Cut area, locality 99g.

Cyclopecten species b

Plate 94, figure 2

The La Boca formation yielded another poorly preserved, relatively large right valve of *Cyclopecten*. It is sculptured with narrow, widely spaced, radial riblets (partly obscured by matrix), which bear conspicuous radially elongate pustules, arranged along widely spaced concentric lines. The anterior auricle is decidedly longer than the left. Whether it is sculptured is indeterminable.

Length 14.5 mm, height 14.5 mm (figured specimen).

This evidently is a new species, characterized by its large size and bold right-valve sculpture. No species as large as these two from the La Boca is on record from the Tertiary Caribbean province.

Occurrence: La Boca formation (early Miocene), Summit area, locality 127a.

Cyclopecten oligolepis (Brown and Pilsbry)

Plate 104, figures 9, 12, 13

Pecten (*Cyclopecten*) *oligolepis* Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 64, p. 512, fig. 5, 1913 (Miocene, Canal Zone).

Pecten oligolepis Brown and Pilsbry, Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 203 (assigned to section *Cyclopecten*), 1922 (Miocene, Costa Rica).

Pecten aff. *subhyalinus* Smith, Toula, K. k. Geol. Reichsanstalt Jahrb., v. 61, p. 492, pl. 31, figs. 1a, 1b, 1c, 1911 (Miocene, Canal Zone).

Very small, right valve generally more convex than left. Prodissoconch generally preserved. Right valve generally smooth, exceptionally bearing faint concentric sculpture and still fainter radial sculpture. Left valve generally more or less distinctly sculptured with widely spaced, low concentric lamellae, exceptionally also bearing faint radial sculpture. Right anterior auricle longer than posterior, set off from disk by very narrow byssal fasciole. Left auricles subequal; with one exception, anterior auricle strongly depressed below level of disk, generally sculptured by continuation of lamellae on disk. Byssal notch narrow, moderately deep. No ctenolium. Interior vertically striate area adjoining dorsal margin well developed. A few left valves show faint maculated color pattern of small, elliptical blotches.

Length 3.1 mm, height 3.0 mm (larger figured left valve). Length 3.6 mm, height 3.5 mm (largest specimen).

Type material: Lectotype, herewith designated, right valve illustrated by Brown and Pilsbry, Acad. Nat. Sci. Philadelphia 3843.

Type locality: Gatun Locks excavation, Canal Zone, middle part of Gatun formation.

This minute species, minute even for a *Cyclopecten*, occurs in the three parts of the Gatun formation—a total of 60 valves, left valves far outnumbering right. It is common, however, only in the middle part of the Gatun; in fact, two immature valves are the only representatives in the lower part of the formation and two valves are in a collection from the upper part. A right valve exposed in interior view and a left(?) valve that lacks shell material, both from the La Boca formation, are doubtfully identified as *C. oligolepis*, although they are of the right size for that species.

In size and outline, *C. oligolepis* is most similar to *C. pernomus* (Hertlein, 1935, p. 320, pl. 18, figs. 11–13), a living eastern Pacific species. The auricles of the fossils are less strongly sculptured, and, for the most part, left valves are less convex. Though most species of the genus live in fairly deep water, the depth record for *C. pernomus* is 1 to 194 fathoms (Grau, 1959, p. 34).

Occurrence: La Boca formation (early Miocene), Gaillard Cut area, localities 99e (identification doubtful), 102a (identification doubtful). Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, locality 136a. Middle part, eastern area, localites 139b, 147b, 147f, 147g, 155a, 155c, 157; western area, locality 169. Upper part, eastern area, locality. Deposits of middle Miocene age, Limón Province, Costa Rica (Olsson's (1922) record).

Genus Propeamussium Gregorio

Gregorio, Naturalista Siciliano, Year 3, p. 119, 1884.
Type (orthotype): *Pecten* (*Propeamussium*) *Ceciliae*, Miocene, Sicily.

Propeamussium species

Plate 84, figure 1

Seven valves of a small *Propeamussium* were recovered from muddy siltstone of the Gatuncillo formation at locality 35, a cut on the pipeline road in the Río Fríjol area, northwest of Gamboa. They are internal molds to which bits of shell cling, or the very thin shell is exposed in interior view. The illustrated right valve is in the best condition and is the only one that has intact auricles. The anterior auricle is slightly longer than the posterior. The interior bears eight ribs that end near the shell margin or a considerable distance from the margin. The exterior is unknown.

Length 4.8 mm, height 4.5 mm (figured specimen).

The material is too meager to attempt to assess the affinities of this species.

The 53 species of smaller Foraminifera listed on pages 16–19 of P 306–A were collected at the same locality.

Occurrence: Gatuncillo formation (middle and late Eocene), locality 35.

Propeamussium cf. P. pennyi (Harris)

Plate 92, figure 18

Small, equilateral, subcircular. Exterior sculpture of closely spaced concentric striae partly showing through shell exposed in interior view. Striae seen under high magnification to be minutely pitted. Interior bearing eight ribs (anteriormost and posteriormost not clearly discernible), extending almost to margin of shell.

Length 7 mm, height (incomplete) 5.5 mm (estimated restored height 7 mm) (figured specimen).

The description is based on a right valve that was damaged during examination, including loss of the auricles. It was found in the moderately deep-water facies of the Caimito formation on Pato Horqueto Island, in Gatun Lake. It has the sculpture of *Propeamussium pennyi* (G. D. Harris, *in* Waring, 1926, p. 108, pl. 19, fig. 5) from the Oligocene part of the Cipero formation of Trinidad but is almost twice as large.

Three internal molds, only one of which is complete, are associated with the right valve. They are ovate, have 10 interior ribs, and the complete one is slightly inequilateral. Although the occurrence of two species of *Propeamussium* at this locality is improbable, the molds are identified as *P.* sp. The type of *P. pennyi* is slightly inequilateral, whereas a virtual topotype of that species (USGS 20437), deposited by H. G. Kugler, is equilateral.

Occurrence: Caimito formation (late Oligocene), locality 55a.

Family PECTINIDAE

The Pectinidae, like the Arcidae covered in chapter E, is a highly diversified family. Some 170 names are on record for species and subspecies in the Tertiary Caribbean province, all except 14 of which were based on Caribbean fossils. In the faunas under consideration, 27 species and subspecies in 12 genera and subgenera are represented.

Subfamily PECTININAE

Genus Pecten Muller

Muller, Zoologiae Danicae prodromus, p. 248, 1776.

Type (logotype, Schmidt, Versuch über die beste Einrichtung * * * vorüglich der Conchylien-Summlungen * * *, p. 67, 1818 (not seen, quoted from Stewart, 1930, p. 33-35, and Winckworth, 1944): *Ostrea maxima* Linné living, eastern North Atlantic Ocean and Mediterranean Sea.

Subgenus Oppenheimopecten Teppner

Teppner, Fossilium catalogus, I, Animalia, pt. 15, Lamellibranchiata tertiaria, "Anisomyaria," II, p. 254, 1922 (as subgenus of *Philippia*).

Type (orthotype): *Pecten subbenedictus* Fontannes, Miocene, southern France.

Oppenheimopecten is distinguished from *Pecten* s.s. by its smaller size and the lack of secondary radial sculpture almost invariably present on the valves of *Pecten* s.s.

As noted by Teppner on page 87 of the publication cited above and by Roger (1939, p. 231), Teppner's manuscript ("Die Familie der Pectinidae, ihre Unterfamilien, Gattungen und Untergattungen") was submitted for publication twice but was not published. Teppner, however, sent a copy to Roger, who quoted from it; the diagnosis of *Oppenheimopecten* is quoted from page 242. *Deperetia*, another subgenus of *Phillipia* proposed by Teppner in the same manuscript (p. 259; type (orthotype): *Pecten cristatocostatus* Sacco, Miocene, Italy) and *Philippia* itself (p. 221, not *Philippia* Gray, 1847; type (orthotype): *Pecten arcuatus* Brocchi, Oligocene to Miocene, Italy) are regarded as synonyms of *Oppenheimopecten*, and so is *Convexopecten* (Tucker, 1938, p. 82; type (orthotype): *Pecten josslingi* James Smith, Miocene, Portugal and southern France).

Oppenheimopecten was adopted at the subgeneric level by Grau (1959, p. 148) for tropical eastern Pacific living species and that classification is considered to be appropriate for tropical to warm-temperate fossil and living American species. The type species of *Oppenheimopecten* and many other species occur in the Neogene of southern Europe, but after Pliocene time, the subgenus became extinct in the northern part of the eastern Atlantic Ocean as well as in the Mediterranean Sea. One species, however, survives in the southern part of the eastern Atlantic Ocean: *Pecten turtoni* (Smith, 1890, p. 306, pl. 22, figs. 10, 10a), dredged off St. Helena Island. In America, the earliest species are of late Oligocene age, and the subgenus survives in the western Atlantic and eastern Pacific Oceans.

As interpreted in the present account, *Oppenheimopecten* includes a group of diverse species. The umbonal area of mature right valves extends above the level of the hinge line on the type species (Fontannes, 1878, p. 99, pl. 2, figs. 1-1c) and on other species, but generally is flush with the hinge line. The two valves almost meet along the ventral margin, or the left valve is slightly to relatively deeply recessed within the right and the ribs of the right are extended. The extension has an effect on the fine concentric lamellae, if present, and on the growth lines, both of which are scalloped on the ventral third to two-thirds of mature right valves: arched concave toward the umbo on the ribs and convex toward the umbo in the interribs. No scalloping is evident on right valves of species that have valves that almost meet, or on any left valve, although on left valves of some species lamellae in the interribs are slightly convex.

Among American species, the largest size, deepest recessing of the left valve, and most pronounced scalloping of the right are shown by the eastern Pacific living species named *Pecten cataractes* by Dall (1914a, p. 121; *Pecten dentatus* G. B. Sowerby, 1842, not *Pecten dentatus* J. Sowerby, 1829), which is regarded as a subjective synonym of *Pecten vogdesi*, from the late Pleistocene of California (Arnold, 1906, p. 100, pl. 33, figs. 1, 1a, pl. 34, fig. 1). (For illustrations of living specimens of *P. vogdesi*, see Grau, 1959, p. 149, pl. 55; Olsson, 1961, p. 158, pl. 20, figs. 4-4b). G. B. Sowerby's trivial name was inspired by the dentate, or scalloped, margin of the right valve. Fleming (1957, p. 16) commented on the "dentate" growth lines. The right umbonal area of *P. vogdesi* extends above the hinge line.

The right valve of other tropical eastern Pacific living species is scalloped, but the species are smaller than *P. vogdesi*, and their right umbonal area is flush with the hinge line (Grau, 1959, p. 152-154, pls. 56, 57; Olsson, 1961, p. 158, pl. 20, figs. 3-3c, pl. 21, figs. 3, 3a).

P. raveneli (Dall, 1890-1903, p. 721, pl. 29, fig. 10, 1898) and *P. chazaliei* (Dautzenberg, 1900, p. 228, pl. 10, fig. 1 [4 figs.]), are the sole survivors in western Atlantic waters. The type lot of *P. raveneli*, consisting of three right and two left valves, is from the Pliocene Caloosahatchee formation of Florida. The illustrated right valve is herewith designated the lectotype. The ribs on the ventral part of mature right valves are divided by a shallow groove, and the fine concentric lamellae are scalloped. An articulated Pliocene specimen (USNM 646922) shows that the left valve is slightly recessed and that the ribs of the right are extended. When Dall described his species, he identified as *P. medius* Lamarck the living species now identified as *P. raveneli*. The Pliocene specimens show variation in the width of right interribs. No available living specimens have interribs as narrow as those on a Pliocene valve collected at St. Petersburg, Fla. (USNM 646930). The present range is said to be from North Carolina to the Gulf of Mexico and the West Indies, but no West Indian specimens are in USNM collections.

Pecten (Oppenheimopecten) colpotus Woodring, n. sp.

Plate 110, figures 12, 14

Of medium size, right valve strongly convex, at least central dorsal area of left valve practically flat. Umbonal area of right valve narrow, flush with hinge line. Right valve sculptured with 21 or 22 high ribs, wider than interribs; sides steeply sloping, crest arched. Fine concentric lamellae scalloped. For most part, lamellae worn off on crest of ribs and obscure in many interribs. Anterior auricle set off by deep narrow groove; wide swelling adjoining groove and lower narrower undulations between swelling and dorsal margin. Byssal notch shallow. Posterior auricle not as strongly set off as anterior, not ribbed. Left valve represented only by thin umbonal fragment. Sculptured with 21 ribs, narrower than interribs on ventral part of fragment. On ventral part, fine concentric lamellae extending across ribs and interribs. Auricles depressed, not ribbed.

Length (almost complete) 48.5 mm, height (almost complete) 49 mm, convexity about 20 mm (type).

Type (right valve): USNM 646978; paratype (right valve) USNM 646979.

Type locality: 82 (USGS 16929, Transisthmian Highway, 650 m south-southeast of Río Chilibrillo bridge, Canal Zone), lower member of Alhajuela formation; paratype locality: 83 (USGS 16930, Transisthmian Highway, 400 m north of Río Chagres bridge, Panamá), lower member of Alhajuela formation.

Pecten colpotus, represented by three right valves and an umbonal fragment of a left valve, was found in the lower member of the Alhajuela formation. The ventral margin of the right valves is defective. The scalloped concentric lamellae, especially those in interribs, are shown to best advantage on the posterior ventral part of the paratype (pl. 110, fig. 14).

The late Miocene Venezuelan *P. urumaconis* (G. D. Harris, *in* Hodson, Hodson, and Harris, 1927, p. 22, pl. 13, fig. 1, pl. 14, figs. 3, 4, as *Pecten soror urumaconis*) reaches a larger size (length and height as much as 60 mm) and the right umbonal area is wider than that of *P. colpotus*. Though the scalloped rib growth lines are apparent on the ventral part of the type of the Venezuelan species, the interrib scalloping is visible only on the posterior ventral part, as for the most part the interribs are filled with matrix. The eastern Pacific *P. vogdesi* also is larger, and according to the scalloping of growth lines on the right valve, the left valve is more deeply recessed.

Occurrence: Lower member of Alhajuela formation (early Miocene), localities 82, 83.

Pecten (Oppenheimopecten) reliquus Brown and Pilsbry

Plate 108, figures 1–3

Pecten (*Euvola*) *reliquus* Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 64, p. 510, pl. 23, fig. 3, 1913 (Miocene, Canal Zone).

Pecten reliquus Brown and Pilsbry, Li, Geol. Soc. China Bull., v. 9, p. 254, pl. 1, fig. 7, 1930 (Miocene, Canal Zone).

?*Janira soror* Gabb, Gabb, Acad. Nat. Sci. Philadelphia Jour., 2d ser., v. 8, p. 347, 1881 (Miocene, Canal Zone).

?*Pecten* sp. (vielleicht n. sp.), Toula, K. k. Geol. Reichsanstalt Jahrb., v. 58, p. 755, figs. 12, 13, 1909 (Miocene, Canal Zone).

Of medium size, right valve moderately convex, left valve slightly concave. Right valve sculptured with about 18 inverted U-shaped ribs (9 on estimated anterior half, not including 3 narrow ones at anterior end); wider than interribs on dorsal third, slightly narrower than interribs on ventral third, or wider than interribs on at least dorsal half. Ventral part of ribs divided by shallow groove. Anterior auricle weakly ribbed, posterior auricle unknown. Left valve sculptured with about 18 narrow ribs, narrower than interribs. Posterior auricle not ribbed, anterior auricle unknown. Evenly spaced fined concentric lamellae extending across ribs and interribs on both valves; conspicuous on right valve, though worn on crest of some ribs, for most part worn on available left.

Length (incomplete) 34.9 mm, height (almost complete) 39 mm, convexity about 8 mm (syntype, right valve). Length (incomplete) 34.7 mm, height 50.6 mm (syntype, left valve).

Type material: Two syntypes. Acad. Nat. Sci. Philadelphia 3882.

Type locality: Gatun Dam spillway excavation, Canal Zone, middle part of Gatun formation.

When *Pecten reliquus* was described it was not adequately illustrated. Through the kindness of Dr. H. G. Richards, former Chairman of the Department of Geology, Academy of Natural Sciences of Philadelphia, the syntypes were forwarded on loan and were photographed (pl. 108, figs. 2, 3).

This is a rare species, represented by three incomplete specimens from the middle part of the Gatun formation: two syntypes (a right and a left valve), and a right valve larger than the syntype right. On the larger right valve (pl. 108, fig. 1), the interribs are wider than on the syntype right at the growth stage represented by the ventral margin of the syntype right, and the ribs are divided at an earlier stage. In fact, on the syntype, only some ribs show an almost imperceptible groove at and near the ventral margin. Though the anterior auricle is preserved on both right valves, its margin is defective on both.

The much larger late(?) Miocene Venezuelan *P. codercola* (G. D. Harris, *in* Hodson, Hodson, and Harris, 1927, p. 23, pl. 13, fig. 3, pl. 14, figs. 1, 5, pl. 15, fig. 7, as *Pecten soror codercola;* length up to 70 mm) has similar divided right ribs. The status of the early Miocene Puerto Rican *Pecten reliquus portoricoensis* (Hubbard, 1920, p. 86, pl. 10, fig. 4), based on left valves, awaits findings of right valves.

The splitting of ribs on the ventral part of right valves recalls *P. raveneli,* mentioned in the discussion of the subgenus. The right valve of that species, however, is more convex than that of *P. reliquus,* and the ribs on the ventral part are wider than those on the larger specimen from the Gatun formation.

Pecten opercular iformis (Toula, 1909, p. 712, pl. 26, fig. 3), a species from the Gatun formation, has not been recognized in the collections under study.

Occurrence: Middle part of Gatun formation (middle Miocene), eastern area, locality 147a, Gatun Dam spillway excavation (Brown and Pilsbry's record).

Subgenus Euvola Dall

Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 4, p. 694, 1898.
Type (orthotype): *Pecten ziczac* Linné, living North Carolina and Bermuda to northern Brasil.

The subgenus *Euvola* is characterized by greatly subdued sculpture, especially on the right valve. The allegation that it has only one pair of cardinal crura (Woodring, 1925, p. 63) was not well founded. To be sure, on valves of the type species, the slender pair near the dorsal margin are the only well-developed crura; one or two other pair are poorly developed or absent. That arrangement, however, is not shown by *Pecten laurenti.*

Euvola is now endemic in the western Atlantic Ocean, where it is represented by the type species and *P. laurenti.* The record in the Tertiary Caribbean province—the only western Atlantic area where fossil species are known—extends back to middle Miocene. In late Neogene time, *Euvola* gained a temporary footing in the eastern Pacific, where it is represented in the Imperial formation of the Salton trough, north of the head of the Gulf of California, by *Pecten keepi* (Arnold, 1906, p. 60, pl. 5, fig. 1, pl. 6, figs. 1, 1a; Durham, 1950, p. 61, pl. 6, figs. 5, 6). Whatever the age of the Imperial formation may be—late Miocene or early Pliocene—some of its fossils have Miocene Caribbean affinities. Moreover, they include the only eastern Pacific species of *Cassis* and *Euvola,* both of which have been in the Caribbean region since middle Miocene time.

Pecten (Euvola) bowdenensis Dall

Plate 104, figures 3, 4, 8

Pecten (Euvola) bowdenensis Dall, Wagner Free Insti. Sci. Trans., v. 3 pt. 4, p. 713, pl. 29, fig. 1, 1898 (Miocene, Jamaica). Woodring, Carnegie Inst. Washington Pub. 366, p. 63, pl. 7, figs. 8, 9, 1925 (Miocene, Jamaica).

Not *Pecten (Euvola) bowdenensis* Dall, Böse, Inst. Geol. México Bol. 22 p. 27, pl. 1, figs. 8, 10, 1906 (Miocene, Oaxaca). Anderson, California Acad. Sci. Proc., 4th ser., v. 18, no. 4, p. 157 (Miocene, Colombia). Perrilliat Montoya, México Univ. Nac., Inst. Geología, Paleontología Mexicana, no. 8, p. 15, pl. 2, figs. 11–14, 1960 (Miocene, Veracruz). Mongin, Bull. Am. Paleontology, v. 54, no. 245, p. 477, 1968 (Miocene, Guadelope).

Not *Pecten (Euvola)* cf. *bowdenensis* Dall, Olsson, Neogene mollusks from northwestern Ecuador, p. 34, pl. 4, fig. 2, Paleontological Research Inst., 1964 (Miocene, Ecuador).

Small, right valve strongly convex, left valve concave. Auricles subequal so far as known, strongly depressed. Right valve sculptured with about 19 very low, flat ribs, separated by linear grooves. Fine concentric lamellae extending across ribs and grooves; worn off on much of shell. Posterior auricle not ribbed, anterior auricle unknown. Left valve sculptured with 18 very low flat main ribs, narrower than interribs. An interstitial riblet in some interribs on ventral third. Fine concentric lamellae, extending across ribs and interribs conspicuous on ventral two-thirds. Auricles not ribbed.

Length (incomplete) 17 mm (estimated restored length 30 mm), height (almost complete) 28 mm, convexity 9.5 mm (illustrated smaller right valve). Length 27.8 mm, height 26.4 mm (illustrated left valve).

Type material: Lectotype, herewith designated, the left valve illustrated by Dall, USNM 135782.

Type locality: Bowden, Jamaica, Bowden formation.

The upper part of the Gatun formation in the western area yielded two incomplete right valves at locality 182a and a left valve at locality 184. All are small and presumably are immature. The right valves are like immature valves of *Pecten bowdenensis* but are also like immature valves of the living *P. ziczac* (Warmke and Abbott, 1961, p. 167, pl. 4, fig. a, pl. 32, fig. h). The left valve, however, has the relatively wide interribs of *P. bowdenensis*, and the auricles, like those of *P. bowdenensis*, lack the radial ribbing of *P. ziczac*. The height of the largest right topotype of *P. bowdenensis* is 44.5 mm, whereas that of the largest *P. ziczac* in USNM collections is 103 mm.

Dall illustrated a relatively small left syntype, not the largest, the dimensions of which were specified in his text. No complete right valve was at his disposal.

Böse, Olsson, and Mongin had only left valves. The height of the ribs, as illustrated by Böse and shown by Olsson's specimen, and the relative width of ribs and interribs, as described by Mongin, suggest they were dealing with species of the subgenus *Oppenheimopecten*. A specimen from the Tubará formation indicates the same for Anderson's record. Topotypes of Perrilliat Montoya's species, including a right valve at a later growth stage than hers (USGS 22279, height 39.8 mm), show that it is related to *P. raveneli*.

Occurrence: Upper part of Gatun formation (middle Miocene), western area, localities 182a, 184. Bowden formation (middle Miocene), Jamaica.

Status of Amussiopecten Sacco

Sacco, I molluschi dei terreni terziarii del Piemonte e della Liguria, pt. 24, p. 55, 1897.

Type (orthotype): *Flabellipecten flabelliformis* (Brocchi) (*Ostrea flabelliformis* Brocchi), Miocene and Pliocene, Italy.

Status of Amussiopecten Sacco

No marked discontinuity is apparent between *Flabellipecten* and *Amussiopecten* (Sacco, 1897, p. 53; type (orthotype): *Pecten burdigalensis* Lamarck, Miocene, southern Europe). The low height of the ribs, their suppression on the ventral part of the shell, and the relatively slight convexity of the right valve—features attributed to *Amussiopecten*—are a matter of degree as compared with species of *Flabellipecten*. If the view, here proposed, that *Amussiopecten* is to be suppressed is adopted, an appeal should be made to the International Commission on Zoological Nomenclature for the conservation of *Flabellipecten*, despite the two-page precedence of *Amussiopecten*.

Group of Flabellipecten gatunensis

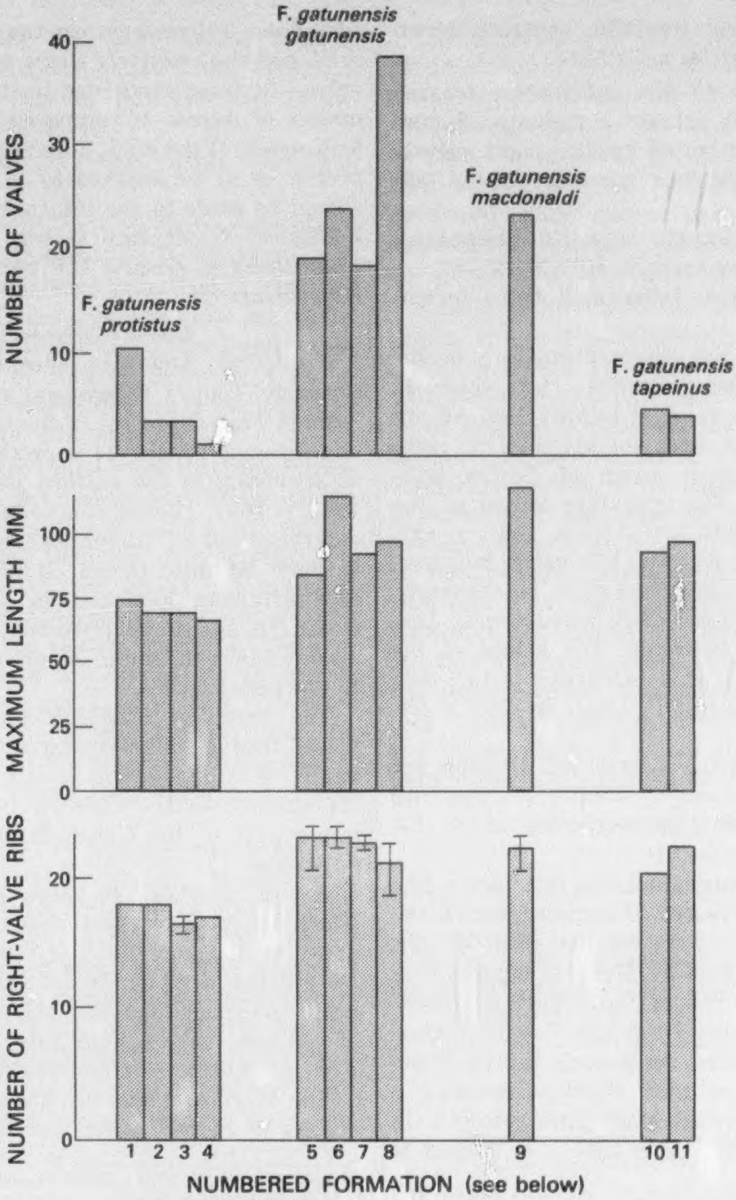
Until 1961, American paleontologists did not take seriously Toula's assignment of his *Pecten gatunensis* to *Flabellipecten*. In the same year that genus, or subgenus, whichever is preferred, was recognized as surviving in the eastern Pacific Ocean (Olsson, 1961, p. 160). That is, it is to be added to the steadily enlarging list of paciphiles, as it is extinct in the western Atlantic Ocean. It is extinct also in the Mediterranean Sea and in the eastern Atlantic Ocean. Its age range in western Europe is early Miocene to Pliocene, and in America from late Oligocene to the present time.

The group of *Flabellipecten gatunensis* can be traced through nine stratigraphic units, ranging in age from late Oligocene to late Miocene or Pliocene. Its absence in the Culebra formation and in the upper part of the Gatun formation represents the only gaps.

A total of some 140 valves is available, many of which are more or less incomplete. It is the greatest array of the genus so far found in the Americas. Despite the large number of valves, only eight specimens are articulated, and only three of those consist of complete valves. Four subspecies are recognized. Figure 5 shows their distribution, number of valves,

The diagnostic features and age range of the subspecies of *Flabellipecten gatunensis* are as follows:

Subspecies	Diagnostic features	Age range
F. gatunensis tapeinus	Of medium size; both valves slightly convex; right-valve ribs very low.	Middle to late Miocene or Pliocene.
F. gatunensis macdonaldi	Large; right valve moderately convex; right-valve ribs almost invariably low.	Late Miocene or Pliocene.
F. gatunensis gatunensis	Of medium size to large; right valve almost invariably moderately convex; right-valve ribs almost invariably strong.	Late early to middle Miocene.
F. gatunensis protistus	Smallest size; right valve slightly convex; smallest number of ribs.	Late Oligocene to early part of early Miocene.



1. Caimito formation
2. Caraba formation
3. Panama formation
4. La Boca formation
5. Lower member of Alhajuela formation
6. Upper member of Alhajuela formation
7. Lower part of Gatun formation
8. Middle part of Gatun formation
9. Toro limestone member of Chagres sandstone
10. Middle part of Gatun formation
11. Chagres sandstone proper

FIGURE 5.—Distribution of subpecies of *Flabellipecten gatunensis*, number of valves, maximum length, and histogram peak and range of number of right-valve ribs. Length estimated for *F. gatunensis protistus* and *F. gatunensis gatunensis* in middle part of Gatun formation.

maximum length, and histogram peak and range of number of right-valve ribs.

The fourth, third, and second subspecies of the preceding table, in descending order, are interpreted as an unbroken main lineage. *F. gatunensis tapeinus* diverged from the main lineage in middle Miocene time and continued in the upper Miocene or lower Pliocene Chagres sandstone proper, which yielded the type. The fossils of the Chagres proper indicate moderately deep water. Those that are associated with that subspecies in the middle part of the Gatun formation, however, indicate water of moderate depth.

All the subspecies have fine concentric lamellae on both valves, but on many specimens the lamellae have been effaced, especially on the ribs of right valves. With the exception of a middle Gatun left valve, which has faint riblets on the auricles and still fainter ribbing on the anterior auricle of a Chagres right valve, the auricles lack radial ribbing. All have a shallow byssal notch, a pair of cardinal crura, and on both valves interior paired lirae, like those of *Amusium*, that extend upward a variable distance from the ventral margin. These features are not repeated in the descriptions, except that the length of the lirae is specified so far as known. In counting ribs, faint riblets, one or two of which are present or absent at the extreme anterior and posterior ends (Conrad's submargins), were omitted. Left-valve ribs are almost invariably a few less than those of right valves. The height and length of *F. gatunensis protistus* are about equal, whereas in the other subspecies, the height is 84 to 96 percent of the length.

Flabellipecten gatunensis protistus Woodring, n. subsp.

Plate 87, figure 15; plate 92, figures 10, 16, 17.

Of medium size, right valve slightly convex, left valve practically flat to slightly convex. Right valve sculptured with 16 to 20 inverted U-shaped ribs (histogram peak at 18); strong throughout, except at posterior end, at least to height of 46 mm, or lower on ventral third. Ribs wider to much wider than interribs. Left valve sculptured with 16 to 18 ribs, inverted U-shaped throughout, or lower and more arched on ventral third. Ribs narrower than interribs, or of about same width. Interior lirae fading out short distance from ventral margin.

Length (almost complete) 71 mm, height (practically complete) 73 mm, convexity about 7 mm (type). Length 72.3 mm, height 72.9 mm (paratype).

Type (thin-shelled right valve) USNM 646974. Paratype (thin-shelled left valve) USNM 646975. Paratype (thick-shelled right valve) USNM 646976. Paratype (thick-shelled left valve) USNM 646977.

Type and paratype locality: 56 (USGS 6025, about 200 m south of southern end of switch at Bohio Ridge station, relocated Panama Railroad (south side of Bohio Peninsula), Canal Zone), Caimito formation. Paratype locality: 60 (USGS 17685, northward-flowing tributary of Río Mandinga, pebbly calcareous tuffaceous sandstone, 3.31 km southwest of west end of Gamboa bridge), Caraba formation.

Flabellipecten gatunensis protistus is identified in three late Oligocene formations and one early Miocene (the early half of early Miocene)—a total of 19 valves. The specimens from the Panamá formation lack the outermost part of the shell and that from the La Boca is an external mold.

The type was chosen as the most complete right valve, although it cannot be properly cleaned. It and the accompanying left-valve paratype of about the same size are thin shelled, so thin that they are translucent, and their ribbing is subdued on the ventral part. An incomplete thick-shelled right-valve paratype (pl. 92, fig. 10) has ribbing like that of the typical form of the nominate subspecies. The two thin-shelled and nine thick-shelled incomplete valves collected at the type locality presumably represent different environments. Whether they were found in the same bed is not known. A strongly ribbed left-valve paratype, from the Caraba formation, is shown on plate 87, figure 15.

This subspecies is smaller than the nominate subspecies and has fewer ribs: 16 to 20 on right valves (histogram peak at 18), compared with 20 to 24 (peaks at 22 and 23). One middle Gatun right valve of the nominate subspecies is only slightly convex, and the ribs of a few right valves and of one left valve are subdued.

One other late Oligocene American *Flabellipecten* is on record: the Antiguan species, *Pecten duplex* (Cooke, 1919, p. 140, pl. 11, figs. 10a, 10b), which was assigned to *Flabellipecten* by Olsson and Richards (1961, p. 5, pl. 1, figs. 5, 6) when they recorded it from the Guajira Peninsula of Colombia. The ventral part of its ribs on both valves is divided.

Occurrence: Caimito, Caraba, and Panamá formations (late Oligocene), and La Boca formation (early Miocene). Caimito formation, localities 56, 57a (*Flabellipecten*? sp.). Caraba formation, locality 60. Panamá formation, locality 44. La Boca formation, Gaillard Cut area, locality 102a.

Flabellipecten gatunensis gatunensis (Toula)

Plate 104, figures 1, 2, 10; plate 107, figures 3, 6; plate 110, figure 13; plate 113, figure 18

Pecten (*Flabellipecten*) *gatunensis* Toula, K. k. Geol. Reichsanstalt Jahrb., v. 58, p. 711, pl. 26, fig. 2, 1909 (Miocene, Canal Zone).

Pecten gatunensis Toula, Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 63, p. 365, 1911 (Miocene, Canal Zone). Olsson, Bull. Am. Paleontology, v. 9., no. 39, p. 197, pl. 16, figs. 3, 4, 1922 (Miocene, Canal Zone, Panamá). Hodson, Hodson, and Harris, Bull. Am. Paleontology, v. 13, no. 49, p. 24, 1927 (Miocene, Venezuela).

?*Pecten gatunensis* Toula?, Haas, Jour. Paleontology, v. 16, p. 309 (list), 1942 (Miocene, Costa Rica).

Pecten (*Flabellipecten*) *gatunensis gatunensis* Toula, Woodring, *in* Woodring and Malavassi, Jour. Paleontology, v. 35, p. 494, pl. 70, figs. 2, 4, 5, 1961 (Miocene, Costa Rica).

Pecten (*Flabellipecten*) *gatunensis* Toula, Olsson, Neogene mollusks from northwestern Ecuador, p. 35, pl. 4, figs. 5, 5a, Paleontological Research Inst., 1964 (Miocene, Ecuador).

?*Pecten* sp., Toula, K. k. Geol. Reichsanstalt Jahrb., v. 58, p. 755, fig. 12, 1909 (Miocene, Canal Zone).

Pecten flabelliformis Defr. [Brocchi], Toula, K. k. Geol. Reichsanstalt Jahrb., v. 58, p. 756, fig. 14, 1909 (Miocene, Canal Zone).

Pecten (*Pecten*) sp. (see explanation of Durham's plate), Durham, Geol. Soc. America Mem. 43, p. 60 (in discussion), pl. 7, fig. 2, 1950 (Miocene, Venezuela).

Of medium size to large, right valve almost invariably moderately convex, exceptionally slightly convex, left valve barely convex along midline of length, lateral margins generally slightly upturned. Right valve sculptured with 20 to 24 ribs (histogram peaks at 22 and 23); generally inverted U-shaped, almost invariably strong throughout, exceptionally subdued and more arched; exceptionally divided near ventral margin by one or two very shallow grooves; exceptionally an interstitial riblet. Ribs wider to much wider than interribs. Left valve sculptured with 16 to 20 ribs (histogram peaks at 18 and 19); generally lower than ribs on right valve; exceptionally an interstitial riblet. Ribs almost invariably narrower than interribs. Interior lirae generally fading out short distance from ventral margin, exceptionally extending halfway to umbonal area.

Length (incomplete) 73 mm (estimated restored length 77 mm), height (incomplete) 69 mm (estimated restored height 72 mm), convexity about 11 mm (smaller figured right valve from Gatun formation). Length 116.5 mm, height 98 mm, convexity about 20 mm (figured right valve from upper member of Alhajuela formation, largest specimen).

Type: Paläontologisches Inst., Univ. Wien.

Type locality: Presumably Gatun Locks excavation, Canal Zone, middle part of Gatun formation.

Flabellipecten gatunensis gatunensis occurs in the Alhajuela formation and continues through the lower and middle parts of the Gatun formation. A total of some 90 valves is available. Loose right valves outnumber loose left by a margin of 24 percent.

The earliest appearance is in the lower member of the Alhajuela (pl. 104, figs. 1, 2). As is evident in text-figure 5, the largest specimens are in the upper member. The largest collected is illustrated on plate 104, figure 10. The largest number is from the middle part of the Gatun, which yielded the type. Plate 113, figure 18, represents a typical strongly ribbed right valve as the nominate subspecies occurs in the Gatun. The ribs of a right valve from locality 140 and of another from locality 141 are exceptionally low, and those of a left valve from locality 141 also are exceptionally low. The lower part of the Gatun yielded a relatively thin right valve (pl. 107, figs. 3, 6) notable for its long interior lirae. Its ribs are subdued on the ventral part.

Pecten sericeus (Hinds) was recognized by Olsson (1961, p. 160, pl. 19, figs. 3, 3a, pl. 21, fig. 4) as a survivor in the eastern Pacific Ocean. *P. lunaris* Berry (Keen, 1971, p. 85, fig. 176), dredged off Sonora, is closely related to *P. sericeus*. *P. diegensis* Dall (Grau, 1959, p. 143, pls. 52, 53), suggested by Olsson as a close ally of *P. sericeus*, has a much more northern range than *P. sericeus* and *P. lunaris*, as far north as off Bodega Bay, Sonoma County, California. *P. stearnsii*, which occurs in the Pliocene of southern California, presumably is to be grouped with *P. diegensis*.

Occurrence: Alhajuela formation (early Miocene). Lower member, localities 76, 79, 80, 81, 82, 82a. Upper member, localities 85, 85a, 87, 89, 90, 91. Lower and middle parts of Gatun formation (middle Miocene). Lower part, localities 138, 138c, 138d, 138f, 138h. Middle part, eastern area, localities 139d, 140, 141, 143, 144, 144a, 144b, 144d, 147a, 155, 155b, 159; western area, localities 160a, 160d. Middle Miocene deposits, central Costa Rica. Piojó formation (middle Miocene), Atlántico Dept., Colombia (USGS 11515). Middle Miocene deposits, Falcón, Venezuela. Angostura formation (middle Miocene), Esmeraldas Dept., Ecuador. Limónes formation (late Miocene), Bocas del Toro area, Panamá (Olsson's record).

Flabellipecten gatunensis macdonaldi (Olsson)

Plate 121, figures 3, 10

Pecten MacDonaldi Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 198, pl. 16, figs. 1, 2, 1922 (Miocene, Canal Zone).

Pecten (*Pecten*) *macdonaldi* Olsson, Mansfield, Florida Geol. Survey Bull. 8, p. 57, pl. 14, figs. 5, 6, 1932 (Miocene, Florida). Tucker, Am. Midland Naturalist, v. 17, no. 2, p. 480, pl. 3, fig. 5 (type), 1936 (Miocene, Canal Zone, Florida).

?*Pecten MacDonaldi* Olsson, Hodson, Hodson, and Harris, Bull. Am. Paleontology, v. 13, no. 49, p. 25, 1927 (Miocene, Venezuela; "cf." cited under localities).

Large, right valve moderately convex, left valve barely inflated along midline of length, lateral margins barely upturned. Right valve sculptured with 20 to 23 ribs (histogram peak at 22 and 23); ribs almost invariably low, exceptionally moderately strong, subdued on ventral part of many specimens; wider than interribs; exceptionally divided by shallow groove. Left valve sculptured with 19 ribs, strong throughout, slightly narrower than interribs on available specimen. Interior lirae unknown.

Length (almost complete) 100 mm, height 93.5 mm, convexity about 10 mm (figured topotype right valve sculptured with moderately strong ribs). Length 118 mm, height (incomplete) 75 mm (estimated restored height 110 mm), convexity about 12 mm (largest specimen, topotype right valve).

Type (right valve): Paleontological Research Inst. 21132. Paratype (left valve): Paleontological Research Inst. 21133.

Type locality: West (southwest) of Gatun Locks, Canal Zone, Toro limestone member of Chagres sandstone.

Flabellipecten gatunensis macdonaldi is a large subspecies found in the Toro limestone member, a shallow-water basal member of the Chagres sandstone. Ten of the 14 topotypes collected at locality 188d have a length, or estimated length, of 100 to 118 mm. Both of the illustrated specimens are topotypes from that locality. Twenty-two right valves, but only one left valve, are in the collections.

This subspecies is larger than the nominate subspecies as it occurs in the Gatun formation, but not as it occurs in the upper member of the Alhajuela formation. The ribs of right valves almost invariably are low, like those on plate 121, figure 3. The only right that has moderately strong ribs is shown on plate 121, figure 10.

The late middle Miocene Florida pectinid identified by Mansfield as *F. gatunensis macdonaldi* suggests a small form (length 78.5 mm) of that subspecies. It is the only recorded *Flabellipecten* from southeastern United States.

Occurrence: Toro limestone member of Chagres sandstone (late Miocene or early Pliocene), localities 187 (immature, identification doubtful), 188, 188c, 188d, 188e. Deposits of late middle Miocene age, western Florida.

Flabellipecten gatunensis tapeinus Woodring, n. subsp.

Plate 113, figure 17; plate 122, figures 9, 10

Of medium size, right and left valves slightly convex. Right valve sculptured with 20 to 22 ribs, very low throughout, especially near ventral and lateral margins, where they practically disappear or almost disappear. Ribs wider than interribs. Left valve sculptured with 20 narrow ribs, somewhat subdued near ventral margin, strongly subdued near lateral margins. Ribs narrower than interribs. Interior lirae of small left(?) valve extending about a third of distance from ventral margin to umbonal area.

Length 96.5 mm, height 90 mm, convexity (both valves) 21.5 mm (type).

Type (articulated specimen): USNM 646992.

Type locality: 207 (USGS 16969, Caribbean coast, roadcut on south side of Río Lagarto about 230 m south of Lagarto, Panamá), Chagres sandstone.

Flabellipecten gatunensis tapeinus is represented in the Chagres sandstone by the articulated type and an incomplete left valve. Three right valves and a small left(?), only the interior of which is exposed, from the middle part of the Gatun formation are assigned to it. Both valves of the type are slightly convex and the other left valve from the Chagres also is slightly convex. The right-valve ribs are lower than those of the other subspecies, even lower than those of other subspecies that are subdued near the ventral margin.

Occurrence: Middle part of Gatun formation (middle Miocene), eastern area, locality 139g; Chagres sandstone (late Miocene or early Pliocene), localities 199, 207.

A species of Flabellipecten not in group of F. gatunensis

Flabellipecten antiguensis (Brown)

Plate 96, figures 1–3

Pecten (*Amusium*) *antiguensis* Brown, Acad. Nat. Sci. Philadelphia Proc., v. 65, p. 603, 613, pl. 18, figs. 1–3, 5, 1913 (Oligocene, Antigua; fig. 5, showing beekite rings, is irrelevant). Cooke, Carnegie Inst. Washington Pub. 291, p. 143, pl. 13, figs. 6, 7, 1919 (Oligocene, Antigua).

Amussiopecten antiguensis (Brown), Masuda, Palaeontological Soc. Japan Trans. Proc., n. ser., no. 84, p. 211, pl. 26, figs. 4, 5, 1971 (Oligocene, Antigua).

Not *Pecten antiguensis* Brown, Harris, *in* Waring, The geology of the Island of Trinidad, B.W.I.: Johns Hopkins Univ. Studies in Geology, no. 7, p. 107, pl. 19, fig. 4, 1926 (Miocene, Trinidad).

Amussiopecten woodringi Masuda, Palaeontological Soc. Japan Trans, Proc., n. ser. no. 84, p. 214, pl. 26, figs. 2a, 2b, 3a, 3b, 1971 (Oligocene, Puerto Rico).

Of medium size, height little less than length. Right valve slightly convex, left valve barely convex. Auricles not ribbed, depressed; byssal notch shallow. Right valve sculptured with 18 to 21 ribs; moderately strong for distance of 5 to 10 mm from umbo, greatly subdued on remainder of valve; slightly wider than interribs, or of about same width. Left valve sculptured with 17 or 18 ribs; greatly subdued throughout, or moderately strong in umbonal area to distance of 15 mm; narrower than interribs; or of about same width. Fine, closely spaced concentric lamellae visible on some valves. On right valve, interior paired lirae extending from ventral margin upward for variable distance, as much as two-thirds of distance to umbonal area; lirae showing through to exterior on some valves. On left valve, interior lirae about equidistant, also extending upward for variable distance, as much as two-thirds of distance to umbonal area. A pair of strong dorsal cardinal crura, two other weak pairs, and a pair of elongate auricular crura.

Length (incomplete) 60 mm (estimated restored length 80 mm), height 74 mm (left valve figured in interior view, largest specimen). Length (practically complete) 54 mm, height 50 mm, convexity (both valves) 11 mm (figured articulated specimen).

Type material: Lectotype, herewith designated, the valve illustrated in Brown's figure 1, Acad. Nat. Sci. Philadelphia 1648.

Type locality: Hodge's Bay, Antigua, Antigua formation.

A species of *Flabellipecten*, identified as *F. antiguensis*, like *F. gatunensis protistus*, in the Canal Zone has an age range from late Oliogene to the early part of early Miocene.

Occurrence and number of valves of Flabellipecten antiguensis

Age	Formation		Number of valves
Early Miocene	La Boca	La Boca proper	21 (1 articulated)
		Emperador limestone member	3 (1 articulated)
Late Oligocene	Caimito		3
	Bohio		5

Not only is the largest number from the La Boca proper, but the best preservation also is found in that unit.

The type material of *F. antiguensis* is in poor condition, and the number of ribs is indeterminable. On the largest available topotype (the left valve shown in Cooke's figure 7 and Masuda's figure 5; USGS locality 6862, USNM catalog no. 167139) 18 ribs can be counted in the umbonal area, and about 17 on the small right topotype illustrated in Masuda's figure 4 (USGS 9200b, same locality as 6862, but a different collection and collector; the valve now cataloged as 646993). Despite the deficiencies in the Antiguan specimens, they show the basic features of *F. woodringi*, which was based on well-preserved articulated Puerto Rican specimens.

Though the fossils from the Caimito formation are disfigured by a partial coating of intractable matrix, the right valves show the characteristic ribbing. The Bohio fossils are in better condition, but are incomplete. The collection from La Boca locality 99f includes several partly exposed valves in addition to those tabulated, and others doubtless would appear if the massive calcareous sandstone could be split. The largest, the interior of a left valve, is illustrated on plate 96, figure 3. An articulated specimen is of medium size (pl. 96, figs. 1, 2). The specimen from the Emperador limestone member of the La Boca in Madden basin is articulated and very small (height 33 mm).

Occurrence: Bohio formation (late Oligocene), locality 42d. Caimito formation (late Oligocene), localities 56, 57. La Boca formation (early Miocene), Gaillard Cut area, localities 99f, 119c. Emperador limestone member of La Boca formation (early Miocene), Gaillard Cut area, locality 117b; Madden basin, locality 71. Antigua formation (late Oligocene), Antigua. Lares limestone (late Oligocene), Puerto Rico.

Genus Amusium Roding

Röding, Museum Boltenianum, p. 165, 1798.

Type (logotype, Herrmannsen, Indicis generum malacozoorium, v. 1, p. 47 ("*Amussium*"), 1846): *Ostrea pleuronectes* Linné, living, western Pacific Ocean.

Ten names have been used for Tertiary species in the present Caribbean region. They may be divided into two groups on the presence or absence of riblets in the umbonal area.

Two small specimens from the Quebrancha limestone member of the Caimito formation at locality 62 are listed as *Amusium* sp.

Group of species ribbed in umbonal area

Amusium sol (Brown and Pilsbry)

Plate 98, figure 12

Pecten (*Amusim*) *sol* Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 64, p. 513, pl. 23 (not 24), figs. 1, 2, 1913 (Miocene, Canal Zone).

Of medium size, height little less than length. Right valve slightly convex, left valve very slightly convex. Auricles not ribbed; right auricles slightly more depressed than left; byssal notch shallow. On both valves, riblets extending from tip of umbo for distance of 9 to 12 mm. Interior lirae extending far up from ventral margin. On right valve lirae paired, 13 to 15 pairs. On left valve, lirae generally paired, 12 or 13 pairs, exceptionally equidistant. Lirae showing through to exterior on some valves. A pair of cardinal crura and a pair of elongate auricular crura, ending in a tubercle.

Length (almost complete) 80.5 mm, height (almost complete) 79.5 mm, convexity about 5 mm (figured left valve).

Type material: Lectotype, herewith designated, the valve illustrated in Brown and Pilsbry's figure 2, Acad. Nat. Sci. Philadelphia 3888.

Type locality: "*Pecten* bed" at tower N [Panama Canal, west side of Las Cascadas Reach], Canal Zone, La Boca formation.

All the unequivocally identified valves of *Amusium sol* are topotypes, or virtual topotypes. In three of the four collections, however, exteriors that lack the umbonal area and interiors are doubtfully identified. Brown and Pilsbry's specimens were collected from what they designated as the "*Pecten* bed" at tower N, a signal tower on the pre-Canal alinement of the Panama Railroad. During the construction period, the railroad in that part of Gaillard Cut was close to the west bank of the present canal. MacDonald (1919, p. 537–539) measured 215 feet (65.5 m) of La Boca strata, upward from the base of the formation in the tower N area. He found *A. sol* in his units 16 and 19 near the top of the section (localities 99f and 99g, respectively). Unit 19 presumably is the "*Pecten* bed." The specimens from localities 119 and 119a also are from that unit. At locality 99f, *A. sol* is associated with *Flabellipecten antiguensis;* it is not known to be associated with *Amusium toulae*, the next species, although interiors of the two species are indistinguishable.

In America, umbonally ribbed species of *Amusium* are known only in the Miocene of the Caribbean region. The first described species, *A. lyonii* (Gabb, 1881a, p. 347, pl. 45, figs. 24, 25a, 25b) was collected by Gabb at his unrecognizable early Miocene locality, Sapote [Zapote], on Río Reventazón in northeastern Costa Rica. Though the type material consists of fragments, the auricles are longer than those of *A. sol* and are more depressed.

Occurrence: La Boca formation (early Miocene), Gaillard Cut area, localities 99f and g, 119, 119a.

Amusium mimyum Woodring, n. sp.

Plate 122, figures 2, 3; plate 123, figure 8; plate 124, figure 4

Pecten (*Amussium*) cf. *Mortoni* Rav., Toula, K. k. Geol. Reichsanstalt Jahrb., v. 61, p. 475, pl. 29, fig. 2a, 2b, 1911 (Miocene, Tehuantepec, México).

Of small to medium size, thin-shelled, height generally little less than length, exceptionally little more. Both valves slightly convex. Umbonal area of both valves sculptured with riblets, extending 5 to 16 mm (generally not more than 12 mm) from tip of umbo. Auricles not ribbed; right auricles generally very slightly more depressed than left; byssal notch very shallow, imperceptible on many small valves. Interior lirae generally extending far upward from ventral margin; those of right valve generally weakly grouped into 15 to 17 pairs, or equidistant; those of left valve generally equidistant, or weakly grouped into pairs. A pair of cardinal crura and a pair of elongate auricular crura, ending in a tubercle.

Length 69.9 mm, height 66.5 mm, convexity 6 mm (type, largest specimen). Length 47.5 mm, height 48.6 mm, convexity 6 mm (figured small left valve).

Type (right valve): USNM 647134.

Type locality: 206 (USGS 16937, Caribbean coast near mouth of Río Piña; roadcut on west side of river about 90 m west of road fork, Panamá), Chagres sandstone.

Amusium mimyum, which occurs in the Chagres sandstone, is the youngest of the umbonally ribbed species and, with the exception noted in a following paragraph, is also the smallest.

The distribution of the 65 valves, and the number and maximum length at each locality are shown in the following table:

Distribution of Amusium mimyum, *number of valves, and maximum length*

Locality	Number of valves	Maximum length
199	16	53.3 mm
201	38	47.7 mm
202	2	44 mm
206	8	69.9 mm
208	1	35± mm

It is apparent that the only relatively large specimens are from locality 206, the type being the largest of all. The type is a right valve, but the ventral part of the anterior auricle is defective. The very shallow byssal notch is shown on a smaller right valve from the type locality (pl. 124, fig. 4), a valve that is comparable in size to the largest from other localities. Owing to the equal convexity of the valves, the shallowness of the byssal notch, and the slight difference in depression of the auricles, many small valves are indistinguishable as right or left.

A small right valve (length 42 mm) from the early Miocene Anguilla formation of the island of Anguilla, originally in the Guppy collection, was identified by Dall as *A. lyonii*, cited under the preceding species. Cooke (1919, p. 142, pl. 13, figs. 1a, 1b, 2) also identified as *A. lyonii* two additional Anguillan specimens. The shell of *A. mimyum* is thinner than that of the Anguillan fossils, doubtless correlated with its deeper water habitat, and its auricles are shorter and narrower than those of Cooke's larger specimen (his figs. 1a 1b), which has an estimated restored length of 57 mm. Whether the Anguillan fossils represent a small form of *A. lyonii* is indeterminable at present.

Toula's thin-shelled *Amusium* from Tehuantepec also was identified by Dall as *A. lyonii*, but Cooke thought it was not the same as the Anguillan species. It is represented in USNM collections by an incomplete left valve (135059, estimated restored length 50 mm), which is assigned to *A. mimyum*.

Occurrence: Chagres sandstone (late Miocene or Pliocene), localities 199, 201, 202, 206, 208. Deposits of late Miocene age, Tehuantepec area, México.

Group of species not ribbed in umbonal area

Amusium toulae (Brown and Pilsbry)

Plate 96, figures 5, 7, 8; plate 100, figure 10; plate 108, figures 7, 8; plate 123, figure 7

Pecten (*Amusium*) *gatunensis* Toula, K. k. Geol. Reichsanstalt Jahrb., v. 58, p. 716, pl. 26, fig. 10, 1909 (Miocene, Canal Zone). Not *Pecten* (*Flabellipecten*) *gatunensis* Toula, same publication, p. 711.

Pecten (*Amusium*) *toulae* Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 63, p. 365, pl. 28, fig. 7, 1911 (Miocene, Canal Zone).

Pecten (*Amusium*) *luna* Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 64, p. 514, pl. 24 (not 23), fig. 1, 1913 (Miocene, Canal Zone). Hodson, Hodson, and Harris, Bull. Am. Paleontology, v. 13, no. 49, p. 37, 1927 (Miocene, Venezuela). Li, Geol. Soc. China Bull., v. 9, p. 256, pl. 2, fig. 14 (unrecognizable, but see Pilsbry, 1931, under next entry), 1930 (Miocene, Canal Zone). Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 83, p. 429, 1931 (Miocene, Canal Zone).

Amusium luna (Brown and Pilsbry), Olsson Bull. Am. Paleontology, v. 9, no. 39, p. 205, pl. 17, fig. 1, 1922 (Miocene, Canal Zone, Costa Rica). Weisbord, Bull. Am. Paleontology, v. 14, no. 54, p. 13, pl. 3, fig. 1, 1929 (Miocene, Colombia). Pilsbry Acad. Nat. Sci. Philadelphia Proc., v. 83, p. 434, pl. 41, fig. 1, 1931 (Miocene, Canal Zone).

Pecten (*Amusium*) cf. *Mortoni* Ravenel, Toula, K. k. Geol. Reichsanstalt Jahrb., v. 58, p. 714, pl. 26, fig. 8, 9, 1909 (Miocene, Canal Zone).

?*Pecten* (*Amusium*) sp., Li, Geol. Soc. China Bull., v. 9, p. 257, pl. 3, fig. 15 (unrecognizable), 1930 (Miocene, Canal Zone). Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 83, p. 429, 1931 (Miocene, Canal Zone).

Of medium size to large, height generally little less than length, exceptionally about equal to length. Right valve slightly convex, left valve very slightly convex. Auricles not ribbed; right auricles, especially anterior one, slightly more depressed than left; byssal notch shallow. Concentric sculpture especially strong on few valves. Fine concentric lamellae on right auricles emphasized on dorsal margin of some valves, forming serrate outline. Interior lirae extending far up from ventral margin, showing through to exterior on many valves. Lirae of right valve grouped into 8 to 10 pairs, exceptionally 14 or 15; those of left valve generally equidistant, 16 to 19 lirae; exceptionally paired, 14 to 18 pairs, or only 8 plus a single lira at each end. A pair of cardinal crura and a pair of elongate auricular crura, ending in a tubercle.

Length (almost complete) 79 mm (estimated restored length 83 mm), height 82 mm, convexity (both valves) 14.6 mm (largest figured specimen from La Boca formation). Length 90 mm, height 89.5 mm, convexity about 7 mm (largest figured specimen, Toro limestone member of Chagres sandstone).

Type: Right valve, Acad. Nat. Sci. Philadelphia 1752.

Type locality: Gatun Locks excavation, Canal Zone, middle part of Gatun formation.

It is unfortunate that *Amusium toulae* has precedence over *A. luna*, as the type of *A. luna* is much the better. The "gray rays," emphasized in the description of *A. toulae*, are not exterior features; they are due to interior lirae showing through to the exterior.

In the Canal Zone *A. toulae* has an age range of early to late Miocene or early Pliocene. The distribution of the 130 available valves, number of valves, number of articulated specimens, and maximum length are tabulated as follows:

Distribution of Amusium toulae, *number of valves, number of articulated specimens, and maximum length*

Age	Formation		Number of valves	Number of articulated specimens	Maximum length in mm
Early Pliocene or Late Miocene	Toro limestone member of Charges sandstone		4	--	90
Middle Miocene	Gatun	Upper part, western area	2	--	80±
		Middle part	16	1	88.8
Early Miocene	Alhajuela	Upper member	5	--	112
		Lower member	7	--	80±
	La Boca formation at Las Cruces		5	2	83±
	Gaillard Cut area La Boca	La Boca proper	89	28	89.5
		Emperador limestone member	2	1	85

The largest specimens, like the largest of the *Flabellipecten gatunensis* lineage, are found in the upper member of the Alhajuela formation and the Toro limestone member of the Chagres sandstone. The large number of valves and large number of articulated specimens in the La Boca formation are noteworthy. The dorsal lateral margins of all the valves from the La Boca are defective, producing a false impression of the outline, which is shown to better advantage by the illustrations of two valves from the Gatun formation (pl. 108, figs. 7, 8). The tedious cleaning of the left valve from the Gatun was abandoned after the dorsal third was cleaned.

Though concentric sculpture generally is weak or practically absent, it is strong on five articulated specimens collected at locality 101h, one of which is illustrated (pl. 100, fig. 10). A serrate dorsal margin on right auricles is shown on plate 96, figure 5. That feature appears on many pectinids and propeamussiids.

A. papyraceum (Gabb) (Pilsbry, 1922, p. 413, pl. 43, figs. 8, 9; Miocene, Dominican Republic) was the first of the Caribbean species of this group to be named. That name has been widely used for Caribbean fossils ranging in age from late Oligocene to Pliocene, as well as for the living species ranging from the Gulf of Mexico and Florida to northern Brasil. In the Dominican Republic, *A. papyraceum* occurs in both the Cercado and Gurabo formations. The largest specimens, represented by fragments, indicate a length of about 90 mm, although the type is 54 mm long. A collection from the Gurabo formation (USGS 8535) contains the only well-preserved specimens in USNM collections. The largest in that collection is comparable in size to the type and, like the type, has relatively short narrow auricles, like those of *A. toulae*. Unlike the fossils from Panamá, however, all of some 30 fragments and specimens from both the Ceracado and Gurabo have paired interior lirae that fade out a short distance from the ventral margin. A form that has long wide auricles, represented by fragments, is found in the Cercado (USGS 8526) and the Gurabo (USGS 8518).

It seems strange that no species is living in the eastern Pacific Ocean.

Occurrence: La Boca formation (early Miocene), Gaillard Cut area, localities 99d, 99e, 99h, 101f, 101h, 120a; Las Cruces area, locality 94. Emperador limestone member of La Boca formation (early Miocene), Madden basin, locality 73 (*Amusium* sp.); Gaillard Cut area, locality 117c. Alhajuela formation (early Miocene). Lower member, localities 75, 76. Upper member, locality 86. Middle and upper parts of Gatun formation (middle Miocene). Middle part, eastern area, localities 144d (*Amusium* sp.), 152 (*Amusium* sp.), 154, 155, 155b, 159d (*Amusium* sp.); western area, localities 160, 160a, 161c. Upper part, western area, localities 181, 182, 185. Toro limestone member of Chagres sandstone (late Miocene or early Pliocene), localities 195 (*Amusium* sp.), 196. Deposits of middle Miocene age, Limón Province, Costa Rica. Deposits of middle or late Miocene age, Falcón, Venezuela. Usiacurí formation (late Miocene), Atlántico Dept., Colombia.

Subfamily CHLAMYDINAE

Genus Chlamys Roding

Röding, Museum Boltenianum, p. 161, 1798.

Type (logotype, Herrmannsen, Indicis generum malacozoorum, v. 1, p. 231, 1846): "*Pecten islandicus* Linn." [*Ostrea islandica* Gmelin = *Pecten islandicus* Müller], living, Arctic Ocean, eastern and western North Atlantic Ocean.

As in other Tertiary tropical faunas, this ancient genus has a meager representation of small species.

Chlamys anguillensis (Guppy)

Plate 94, figure 6

Pecten anguillensis Guppy, Sci. Assoc. Trinidad Proc., v. 1, p. 175, 1867 (Miocene, Anguilla; reprinted, Bull. Am. Paleontology, v. 8, no. 35, p. 54, 1921). Guppy, Geol. Mag., 2d decade, v. 1, p. 443 (list), 446 (explanation of plate), pl. 18, fig. 24, 1874 (Miocene, Anguilla).

Pecten (*Chlamys*) *anguillensis* Guppy, Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 4, p. 715, 1898 (Oligocene, Antigua; Miocene, Anguilla). Brown, Acad. Nat. Sci. Philadelphia Proc., v. 65, p. 602, pl. 18, figs. 4, 6–8, 1913 (Oligocene, Antigua). Cooke, Carnegie Inst. Washington Pub. 291, p. 132, pl. 10, figs. 1a, 1b, 2, 1919 (Oligocene, Antigua; Miocene, Anguilla).

?*Chlamys* (*Chlamys*) *anguillensis* (Guppy), Mansfield, Florida Geol. Survey Bull. 15, p. 206, pl. 14, fig. 6, 1937 (Miocene, Florida).

Small. Right valve sculptured with 11 wide and widely spaced ribs, of about same width as interribs, or little narrower. Ribs obscurely and irregularly noded (at least on ventral half), and weakly grooved near ventral margin. Byssal notch apparently shallow. Exterior of anterior auricle not preserved. Posterior auricle very short, apparently not ribbed. Left valve unknown.

Length 22.4 mm, height 26.6 mm, convexity about 7 mm (figured specimen).

Type material: Lectotype, herewith designated, USNM 115532.

Type locality: Anguilla, Anguilla formation.

The single right valve of this *Chlamys* from the La Boca formation cannot be cleaned; in fact, it was badly damaged when cleaning was attempted. It has the basic right-valve features of *C. anguillensis*. Cooke thought that the articulated specimen from the Guppy collection he illustrated (pl. 10, figs. 1a, 1b) is the type; that is, Guppy's poorly illustrated specimen. It is now designated the lectotype (length 29.8 mm, height 33 mm). Its right-valve interrib spaces are narrower than those of the fossil from the La Boca.

The articulated specimen from Antigua illustrated by Cooke (pl. 10, fig. 2) has much stronger secondary radial sculpture than has any Anguillan specimen. On another Antiguan specimen (USNM 154175), however, the secondary sculpture is not so strong.

Though Mansfield's incomplete valve from the Tampa limestone has the right-valve ribbing of *C. anguillensis*, the length seems to be too great for the estimated height.

Occurrence: La Boca formation (early Miocene), Gaillard Cut area, locality 119. Antigua formation (late Oligocene), Antigua. Anguilla formation (early Miocene), Anguilla. Tampa limestone (early Miocene), Florida (identification doubtful).

Chlamys sentis (Reeve)?

Plate 100, figure 9

Small. Sculptured with about 40 very narrow, closely spaced ribs, wider than interrib spaces. Some ribs divided into two branches on ventral part. Ribs bearing low scales, generally partly or entirely effaced. An interstitial riblet in some interrib spaces. Auricles ribbed. Posterior auricle very short. Ventral margin of right anterior auricle defective.

Length (practically complete) 26.2 mm, height 29.9 mm, convexity about 7 mm (figured specimen).

Two right valves and an articulated specimen, all in poor condition, from coralliferous limestone in the Emperador limestone member of the La Boca formation, are doubtfully identified as the living Caribbean *Chlamys sentis* (Warmke and Abbott, 1961, p. 168, pl. 33, fig. c). So far as they go, they show the features of that species.

Occurrence: Emperador limestone member of La Boca formation (early Miocene), Gaillard Cut area, locality 117a.

Chlamys species

Plate 100, figure 5

Small. Left(?) valve sculptured with 25 ribs, slightly wider than interrib spaces. Ribs bearing widely spaced vaulted constrictions, convex toward umbo. Vaults effaced on dorsal part, but constrictions remaining. Auricles missing.

Length (practically complete) 26 mm, height (incomplete) 28 mm (estimated restored height 30 mm), convexity about 3 mm (figured specimen).

Coralliferous limestone of the Emperador limestone member of the La Boca yielded another species of *Chlamys*, represented by an incomplete valve, which cannot be cleaned properly. The slight convexity indicates that it is a left valve.

Vaulted scales are not unusual in the genus, but vaulted constrictions appear to be unique.

Occurrence: Emperador limestone member of La Boca formation (early Miocene), Gaillard Cut area, locality 118a.

Subfamily?

Genus Aequipecten Fischer

Fischer, Manuel de conchyliologie, p. 944, 1886.

Type (monotype): *Chlamys opercularis* (Linné) (*Ostrea opercularis* Linné), living, eastern North Atlantic Ocean and Mediterranean Sea.

The western Atlantic strongly scabrous species, variously known as *Pecten muscosus* Wood, 1828, *P. exasperatus* Sowerby, 1842, and *P. fuscopurpureus* Conrad, 1849, is traditionally assigned to *Aequipecten*, and that allocation seems to be justified. Its sculptural plan is like that of the type species, although the secondary riblets of *A. opercularis* are so minutely scabrous that the scales generally are effaced on the primary ribs and are apparent only in the interribs. To be sure, the left valve of *A. opercularis* is more convex than the right, whereas *A. fuscopurpureus* and its fossil allies are equivalve or practically equivalve. (Though Conrad's name (Conrad, 1849, p. 209; 1850, p. 280, pl. 39, fig. 10), is chronologically the last of the three, it is given precedence, as was done by Olsson and Harbison (1953, p. 53), on the grounds that it has an unequivocal type locality and the type material is preserved.)

In the Caribbean region *Aequipecten*, in the restricted sense, appeared in the fossil record as early as late Oligocene time. The genus, like *Amusium*, is not living in the eastern Pacific Ocean.

Aequipecten species

Three poorly preserved small valves, parts of which show the typical scabrous sculpture, were recovered from the Caimito formation. Sixteen primary ribs can be counted on one valve, and others may be concealed. The largest has the following dimensions: length (incomplete) 35 mm (estimated restored length 38 mm), height 37 mm, convexity about 9 mm.

This may be a small form of *Aequipecten canalis*, the next species.

Occurrence: Caimito formation (late Oligocene), localities 52, 52a.

Aequipecten canalis (Brown and Pilsbry)

Plate 97, figures 4, 7

Pecten oxygonum canalis Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc. v. 64, p. 511, pl. 24 (not 23), fig. 3, 1913 (Miocene, Canal Zone).

?*Pecten hodgii* Hubbard, Scientific Survey Porto Rico and Virgin Islands, v. 3, pt. 2, p. 93, pl. 12, fig. 5, 1920 (Miocene, Puerto Rico).

?*Pecten* (*Chlamys*) *buchivacoanus* F. and H. Hodson, *in* Harris, Hodson, and Hodson, Bull. Am. Paleontology, v. 13, no. 49, p. 29, pl. 16, figs. 6, 8, 10, 11, 1927 (Oligocene, Venezuela).

Of medium size, height and length subequal, valves of equal convexity or left slightly more convex than right, auricles subequal. Sculptured with 17 to 20 arched primary ribs (generally 18 or 19), generally wider than interribs, exceptionally of about same width. Low blunt scales or nodes appearing on ribs of well-preserved shells at height of 3 to 6 mm. Fine secondary riblets appearing on ribs and interribs at height of about 10 mm or later, or not at all, even at height as great as 40 mm. Low blunt scales on riblets. On many shells, especially on ventral part of mature shells, scales higher and vaulted. On some shells, riblet running down crest of ribs wider and more strongly scabrous than on others. On few immature valves, low concentric lamellae conspicuous in interribs. Ventral margin moderately scalloped. Flanks (Conrad's submargins) bearing fine radial threads or radial sculpture absent. Auricles sculptured with more or less scaly riblets, those on right anterior auricle wider and more scaly than on others. Byssal notch deep, ctenolium short. Only few interiors available. Three posterior cardinal crura and one anterior on a right valve (pl. 97, fig. 4); a pair of auricular tubercles.

Length 40.8 mm, height 40 mm, convexity (both valves 13.2 mm (larger figured specimen). Length 59.5 mm, height 57 mm, convexity about 7 mm (largest specimen, a topotype).

Type material: Lectotype, herewith designated, the valve illustrated by Brown and Pilsbry, Acad. Nat. Sci. Philadelphia 3894.

Type locality: "*Pecten* bed" at tower N, (Panama Canal, west side of Las Cascadas Reach), Canal Zone, La Boca formation.

Though *Aequipecten canalis* occurs in the Alhajuela formation, it is preeminently a species of the La Boca formation (some 190 specimens, ranging in length from 13 to 59.5 mm), especially in the Gaillard Cut area. It is especially abundant in the type region, in the collections from MacDonald's measured section mentioned under *Amusium sol*, including 41 topotypes. Nearly all, however, from all the localities are more or less imperfect, especially in the loss of auricles, and only eight are articulated, five of which were collected at locality 101h. Only six interiors are available.

This species is distinguished by the great range of variation in the development or absence of secondary radial sculpture. The percentage of specimens in three categories for the five largest samples is as follows:

Percentage of specimens of Aequipecten canalis *with respect to secondary radial sculpture in five largest samples from La Boca formation*

Locality	Number of specimens	Percentage		
		Secondary sculpture strong	Secondary sculpture intermediate	Secondary sculpture weak or absent
99d ___	50	14	10	76
99g ___	34	85	3	12
99h ___	21	24	9	67
101h ___	14	79	21	--
120 ____	12	--	--	100

The widening of the riblet running down the crest of ribs and the high, vaulted, relatively widely spaced scales are much more pronounced on many valves of *A. fuscopurpureus* than on *A. canalis*.

Whether *A. hodgii* and *A. buchivacoanus* show any range of variation in the strength or absence of secondary radial sculpture is not known.

Occurrence: La Boca formation (early Miocene), Gaillard Cut area, localities 99a, 99c, 99d, 99f, 99g, 99h, 101e, 101f, 101g, 101h, 114, 119, 119b, 119c, 120, 120a; Summit area, locality 127a (*Aequipecten* sp.); Las Cruces area, localities 94, 94a. Emperador limestone member of La Boca formation (early Miocene), Madden basin, locality 73 (identification doubtful); Gaillard Cut area, locality 117b. Alhajuela formation (early Miocene), lower member, localities 65, 66, 77, 79 (identification doubtful for localities 65 to 79), 80, 82, 84; upper member, localities 88, 90. Deposits of late Oligocene age, Falcón, Venezuela (identification doubtful). Quebradillas (now Aymamón) limestone of Vaughan (1924) (early Miocene), Puerto Rico (identification doubtful).

Aequipecten plurinominis (Pilsbry and Johnson)

Plate 107, figure 5; plate 108, figures 4–6; plate 110, figure 3

Pecten exasperatus Sowerby, Guppy, Geol. Soc. London Quart. Jour., v. 22, p. 294, 1866 (Miocene, Jamaica).

Pecten oxygonum Sowerby, Gabb, Am. Philos. Soc. Trans., n. ser., v. 15, p. 256, 1873 (Miocene, Dominican Republic). Guppy, Geol. Soc. London Quart. Jour., v. 32, p. 532, 1876 (Miocene, Dominican Republic).

Pecten (Aequipecten) thetidis Sowerby, Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 4, p. 714, 1898 (Miocene, Dominican Republic, Jamaica). Maury, Bull. Am. Paleontology, v. 5, no. 29, p. 185, pl. 34, fig. 6, 1917 (Miocene, Dominican Republic).

Pecten plurinominis Pilsbry and Johnson, Acad. Nat. Sci. Philadelphia Proc., v. 69, p. 193, 1917 (Miocene, Dominican Republic). Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 73, p. 411, pl. 45 figs. 1, 2, 1922 (Miocene, Dominican Republic).

Chlamys plurinominis (Pilsbry and Johnson), Mongin, Bull. Am. Paleontology, v. 54, no. 245, p. 478, pl. 40, fig. 2, 1968 (Miocene Guadeloupe).

Chlamys (Aequipecten) plurinominis morantensis Woodring, Carnegie Inst. Washington Pub. 366, p. 67, pl. 8, figs. 4, 5, 1925 (Miocene Jamaica).

Pecten (Aequipecten) plurinominis progresoensis Marks, Bull. Am. Paleontology, v. 33, no. 139, p. 60, pl. 2, fig. 8, pl. 3, figs. 4, 5, 1951 (Miocene, Ecuador).

Pecten buchivacoanus maracaibensis F. and H. Hodson, *in* Harris, Hodson, and Hodson, Bull. Am. Paleontology, v. 13, no. 49, p. 30, pl. 17, fig. 6, 1927 (Miocene, Venezuela).

Pecten buchivacoanus falconensis F. and H. Hodson, *in* Harris, Hodson, and Hodson, Bull. Am. Paleontology, v. 13, no. 49, p. 31, pl. 17, figs. 2–5, 7, 1927 (Miocene, Venezuela).

Resembling *Aequipecten canalis*, but secondary sculpture of valves of suitable size strong or moderately strong, with exception of five small valves (height 17 to 22 mm); scalloping of ventral margin moderate to deep; cardinal crura generally strong, even on small valves (height 17 mm); riblets on dorsal part of right anterior auricle wider than on others.

Length 43.2, height 43.6 mm, convexity (both valves) about 22 mm (figured articulated specimen). Length 45 mm, height 47 mm, convexity about 10 mm (largest specimen).

Type material: Lectotype, the valve illustrated by Pilsbry, as designated in explanation of his plate, Acad. Nat. Sci. Philadelphia 3236.

Type locality: Dominican Republic, Miocene, probably Gurabo formation.

Aequipecten plurinominis is rare in the lower part of the Gatun formation and fairly common in the middle part: a total of 45 specimens, one of which is articulated. The scalloping of the ventral margin of the articulated specimen (pl. 108, fig. 4.) is deeper than on others and deeper than on valves from the Dominican Republic and Jamaica. The illustrated specimens cannot be entirely cleaned without damaging the secondary sculpture, and the sculpture of the left anterior auricle of the articulated specimen is almost entirely effaced.

This species, which seems to be widely distributed, is closely related to *A. canalis* and even more closely to the living *A. fuscopurpureus*. The auricles of mature shells of the fossils are a little shorter than those of mature shells of the living species, and the byssal sinus (under the posterior auricle) is shallower. A wide riblet running down the crest of ribs is absent on all the fossils.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, localities 138, 138c. Middle part, eastern area, localities 139, 139b, 139c, 139g, 140, 141, 143, 143a, 144, 144a, 144b, 152; western area, locality 160. Gurabo formation (middle Miocene), Dominican Republic. Bowden formation (middle Miocene), Jamaica, Deposits of middle Miocene age, Falcón, Venezuela. Progreso formation (middle Miocene), Ecuador.

Genus Lepidopecten Woodring, n. gen.

Type: *Pecten (Aequipecten) scissuratus* Dall, Gatun formation, Canal Zone, middle Miocene.

Small to medium size, thin-shelled, especially left valve; height and length subequal; right valve more convex than left, auricles subequal. Sculpture discrepant on right and left valves. Both valves sculptured with inverted U-shaped ribs of about same width as interribs and concentric sculpture consisting of fine lamellae in interribs and exceptionally on parts of ribs, or replaced on ribs by weak, irregularly developed nodes. On left valve, ribs flanked on both sides by a very thin radial lamella. Narrow space between rib and lamella containing microscopic vaulted scales pointed addorsally, generally partly or completely effaced. Flanks very narrow, steeply sloping. Byssal notch very narrow, ctenolium very short, or notch and ctenolium not discernible.

Lepidopecten is distinguished by the discrepant sculpture, the microscopic sculpture of the left valve, and the greater convexity of the right valve. It is represented by two Miocene species: the type species and the earlier *L. proterus*, both from the Canal Zone.

Lepidopecten proterus Woodring, n. sp.

Plate 97, figures 1–3, 6

Small, right valve about twice as convex as left. Right valve sculptured with 16 to 19 ribs (with few exceptions 18), slightly narrower to slightly wider than interribs. Fine concentric lamellae conspicuous in interribs on some valves, generally more or less effaced, exceptionally extending across ribs, but crest of ribs generally bearing more widely spaced, irregularly developed low nodes. Narrow shallow groove, containing closely spaced curved microscopic pustules, exceptionally appearing on both edges of ribs at height of 10 mm, or appearing at height of 4 mm and near ventral margin of mature valve, microscopic pustular grooves appearing on flanks of ribs. Left valve sculptured with 17 to 19 ribs (generally 17 or 18), noded like those on right valve. Ribs flanked on both sides by a very thin radial lamella appearing at height about 10 mm. Space between rib and lamella containing microscopic pustules (probably base of minute scales), generally partly or completely effaced. Fine concentric lamellae in interribs. Radial sculpture of auricles moderate, slightly stronger on right auricles than on left. Byssal notch very shallow, very narrow. Ctenolium very short. Cardinal crura poorly developed, replaced on some valves by irregular swellings. Vertically striated dorsal area high for size of shell. Pair of auricular tubercles generally present.

Length 22.6 mm, height 22.5 mm, convexity 2.8 mm (type). Length (practically complete) 18.5 mm, height 18.5 mm, convexity 5 mm (paratype). Length 25 mm, height 23, convexity about 6 mm (largest specimen, right valve).

Type (left valve): USNM 647122; paratype (right valve) USNM 647123.

Type and paratype locality: 101h (USGS 23652, Panama Canal, west side of Las Cascadas Reach, Canal stations 1774 to 1778 plus 23 m, near top of canal cliff, Canal Zone), La Boca formation.

Lepidopecten proterus is widespread and locally abundant in the La Boca formation: a total of 150 valves, left valves outnumbering right, but none is articulated. They range in length from 7.6 to 25 mm. Species is especially abundant at the type locality (91 valves, 83 percent of which are left). It occurs also doubtfully in the Culebra formation.

This species is smaller than *L. scissuratus*; the difference in convexity of the two valves is greater, and a byssal notch and ctenolium are discernible. Two exceptional right valves, one of which is illustrated (pl. 97, fig. 3), have some of the sculptural features of left valves.

Occurrence: Culebra formation (early Miocene), locality 112a (identification doubtful). La Boca formation (early Miocene), Gaillard Cut area, localities 99b, 99c, 99f, 99g, 101h, 114, 116a, 119; Las Cruces area, locality 94.

Lepidopecten scissuratus (Dall)

Plate 106, figures 1, 3–5

Pecten (*Aequipecten*) *scissuratus* Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 4, p. 715, pl. 34, fig. 4, 1898 (Miocene, Dominican Republic, Canal Zone). Maury, Bull. Am. Paleontology, v. 5, no. 29, p. 186, 1917 (Miocene, Dominican Republic, Dall's record).

Not *Pecten scissuratus* Dall, Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 63, p. 364 (in discussion), pl. 28, figs. 2, 5, 1911 (Miocene, Dominican Republic). Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 73, p. 411, 1922 (Miocene, Dominican Republic).

Pecten effosus Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 63, p. 364, pl. 28, figs. 4, 6, 1911 (Miocene, Canal Zone).

Pecten (*Aequipecten*) *effosus* Brown and Pilsbry, Hodson, Hodson and Harris, Bull. Am. Paleontology, v. 13, no. 49, p. 31, 1927 (Miocene, Venezuela).

Pecten pinnulatus Toula, K. k. Geol. Reichsanstalt Jahrb., v. 61, p. 491, pl. 30, fig. 3, 1911 (Miocene, Canal Zone).

Not *Pecten pinnulatus* Toula, Anderson, California Acad. Sci. Proc., v. 18, no. 4, p. 156, 1929 (Miocene, Colombia).

Of medium size, right valve more convex than left wherever they are associated, but convexity of both variable, ranging from 2.7 to 6.3 mm for right and 2.4 to 5.2 mm for left. Ribs and concentric lamellae appearing at height of 0.5 mm on well-preserved valves. Right valve sculptured with 16 to 18 ribs (generally 17), slightly narrower to slightly wider than interribs. Concentric lamellae weak or absent on ribs, weak or strong in interribs. Left valve sculptured with 14 to 18 ribs (generally 17 or 18). At height of about 10 mm, a very thin radial lamella appearing on both edges of ribs. Space between rib and lamella filled with crowded low vaulted scales, generally broken down to base, or effaced along parts of some ribs, leaving narrow groove along rib flanks. Concentric lamellae generally conspicuous in interribs. Radial sculpture equal on anterior and posterior auricles; that of right valve moderately strong, that of left valve weak or moderately strong. Byssal notch, byssal fasciole, and ctenolium not discernible, even on smallest right valve (height 9 mm). One or two pairs of cardinal crura and a pair of auricular tubercles generally recognizable.

Length 30.7 mm, height 31 mm, convexity 3.7 mm (type). Length 30 mm, height 29.6 mm, convexity 6 mm (larger figured right valve). Length (incomplete) 25.5 mm (estimated restored length 38 mm), height 38.6 mm, convexity (both valves) 8.2 mm (largest specimen).

Type (left valve): USNM 113670.

Type locality: Recorded as Pontón, Dominican Republic, but that record is rejected in favor of Mount Hope, Canal Zone, upper part of Gatun formation, as was done for *Phos metuloides* (P 306–C, p. 266) and *Terebra spirifera* (P 306–D, p. 409).

Dall well described this species but assigned an erroneous locality to the type. There is no reasonable doubt that it was collected at Mount Hope, presumably by Rowell. The species is unknown in the Dominican Republic. Brown and Pilsbry's *Pecten scissuratus* from that country, which occurs in the Gurabo formation, is not closely related. Dall identified his species in Hill's collection that is thought to have been made at Mount Hope (locality 173a); in fact, the only right valves available to Dall are in Hill's collection.

Lepidopecten scissuratus is found in the middle and upper parts of the Gatun formation: a little more than 100 specimens, including 34 topotypes. The largest specimen—the only one articulated—and the smallest unequivocally identified (height 7.5 mm) are topotypes. The sculpture of the left valve is shown to better advantage on the immature specimen illustrated on plate 106, figure 5, than on the type. The type material of *Pecten effosus* consists of two immature left valves, the larger incomplete.

Occurrence: Middle and upper parts of Gatun formation (middle Miocene). Middle part, eastern area, localities 142, 147b, 147h, 151, 153a, 155, 155a, 155b, 159; western area, localities 160d, 161a, 169 (immature, identification doubtful). Upper part, eastern area, localities 171, 172, 173a, 175, 176, 176a, 177, 177a, 177b, 177c, 177d, 178. Deposits of Miocene age, Falcón, Venezuela (Hodson, Hodson, and Harris' record).

Genus Cryptopecten Dall, Bartsch, and Rehder

Dall, Bartsch, and Rehder, Bernice P. Bishop Mus. Bull. 153, p. 93, 1938.

Type (orthotype): *Cryptopecten alli* Dall, Bartsch, and Rehder, living, Hawaiian Islands.

Though *Pecten cactaceus* is twice as large as *Cryptopecten alli,* its microscopic sculpture is basically like that of *C. alli.* Also like *C. alli* it is thin shelled and occurs in an association indicating moderately deep water, perhaps comparable with the depths at which the Hawaiian species has been dredged—in round figures, 200–250 fathoms.

Cryptopecten cactaceus (Dall)

Plate 124, figures 1, 9–11

Pecten (*Chlamys*) *cactaceus* Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 4, p. 716, pl. 34, fig. 2, 1898 (Miocene, Tehuantepec area, México, Dominican Republic). Böse, K. k. Geol. Reichsanstalt Jahrb., v. 60, p. 222, pl. 12, fig. 2, 1910 (Miocene, Tehuantepec area, México). Maury, Bull. Am. Paleontology, v. 5, no. 29, p. 186, 1917 (Miocene, Dominican Republic, Dall's record).

Pecten (*Chlamys*) *cactaceus* Dall var., Toula, K. k. Geol. Reichsanstalt Jahrb., v. 61, p. 475, figs. 1, 2, 1911 (Miocene, Tehuantepec area, México).

Moderately large, thin-shelled, height almost invariably little less than length, valves of moderate and subequal convexity, auricles subequal. Sculpture of both valves similar. Primary ribs few, 12 to 16 (generally 13), base moderately wide, crest narrow, slightly arched. Outermost layer of outer shell layer preserved in patches on only few valves, forming a crust consisting of concentric lamellae, fused adventrally to next lamella, enclosing vesicules. Effacement of crust reveals fine radial threads, one generally near crest of ribs on each side, 4 to 6 in interribs. Fine concentric lamellae extending across ribs and interribs, forming minute vaulted scales, pointing adventrally, on radial threads, and loops, pointing in same direction, on crest of ribs; also forming loops, pointing addorsally, on space between crest of rib and its adjoining thread, and between threads in interribs. Flanks very narrow, steeply sloping. Radial sculpture of right anterior auricle slightly stronger than that of posterior. Radial sculpture of left auricles weak and subequal. Byssal notch very narrow, very shallow. Ctenolium generally absent, exceptionally consisting of a few short teeth. A pair of poorly defined cardinal crura.

Length 28.3 mm, height 28.7 mm, convexity 3.7 mm (lectotype). Length 49.3 mm, height 48.3 mm, convexity 7 mm (figured right valve). Length 51.9 mm, height 48.1 mm, convexity 8 mm (largest specimen).

Type material: Lectotype, herewith designated the immature right? valve illustrated by Dall, USNM 135058.

Type locality: Km 70 on Ferrocarril de Tehuantepec, Veracruz, México, Spencer's Coatzacoalcos formation, late Miocene.

This characteristic species of the Chagres sandstone is represented by 42 specimens. One is articulated and the range in length is 21.9 to 51.9 mm. An exceptional small right valve (length 22.2 mm, locality 206) has 16 ribs and is more convex than other small valves. It is the only valve that has a rib count of more than 14.

The part of the outermost crust is shown on plate 124, figure 9. The sculpture revealed when it is effaced is shown on the same illustration. With further effacement, the microscopic sculpture is lost.

Though the lectotype is immature (pl. 124, fig. 1), a somewhat damaged mature left valve (practically complete length 44.8 mm) is among the syntypes collected by Spencer. In his description, Dall recorded the approximate dimensions of the mature valve. Böse illustrated a mature left topotype.

Mexican geologists do not use Spencer's name: Coatzacoalcos formation (Spencer, 1897, p. 23). Whether the moderately deep-water strata of late Miocene age, so designated by Spencer, can be fitted into the late Tertiary stratigraphic units now recognized in the Tehuantepec area is uncertain. Spencer's and Böse's fossils were collected in railroad cuts, which now are weathered and overgrown.

Dall recorded *Pecten cactaceus* from the Dominican Republic on the basis of the Gabb collection, but it was not found by Pilsbry when he restudied that collection (Pilsbry, 1922, p. 410). As a matter of fact, a closely related species, or possibly a subspecies of *Cryptopecten cactaceus*, is represented by four small valves (maximum length 31.5 mm) from the Gurabo formation of that country (USGS 8586, 8735).

Fossil species of *Cryptopecten* are unknown in America outside the Caribbean region. The genus survives, however, in western Atlantic waters, where it is represented by *Pecten phrygium* (Dall, 1886, p. 217; 1889, pl. 40, fig. 1). That species ranges from Massachusetts to the Gulf of Mexico and the Lesser Antilles and has a considerable depth range—7 to 156 fathoms. Though most of the some 70 available lots clearly were dead shells, the type, dredged at a depth of 95 fathoms in the Gulf of Mexico, was alive. *C. phrygium* (maximum length 42 mm) is somewhat smaller than *C. cactaceus* and is less thin shelled, and its interrib radial threads are finer and more closely spaced.

Occurrence: Chagres sandstone (late Miocene or early Pliocene), localties 206, 206a, 206b, 208. Spencer's Coatzacoalcos formation (late Miocene), Tehuantepec area, Vera Cruz, México.

Genus Leptopecten Verrill

Verrill, Connecticut Acad. Arts and Sci. Trans., v. 10, p. 69, 1897.

Type (orthotype): *C[hlamys] monotimeris* (Conrad) (*Pecten monotimeris* Conrad), regarded as a subspecies of *Pecten latiauratus* Conrad, living, Monterey California, to Cabo San Lucas, Baja California.

Leptopecten ecnomius Woodring, n. sp.

Plate 105, figures 4–6, 8, 9

Small, height and length subequal, valves of slight to moderate and equal convexity, or left slightly more convex than right, auricles subequal. Valves similarly sculptured. Radial and concentric sculpture appearing at height of 1.5 to 2 mm. Radial sculpture consisting of inverted U-shaped ribs, slightly wider to slightly narrower than interribs; 14 to 17 (generally 16) on right valve, 15 to 17 (generally 16 or 17) on left. Concentric sculpture consisting of fine lamellae; at early stage extending across ribs and interribs, later generally wider and nodelike on ribs, exceptionally continuing like at early stage even to ventral margin. Flanks very narrow. Auricles of immature valves large for size of shell. Radial sculpture stronger on right anterior auricle than on left. Radial sculpture weak or absent on both posterior auricles. Conspicuous concentric lamellae on anterior auricles of some immature valves. Byssal notch deep, moderately wide. Ctenolium long for size of shell. A pair of slender cardinal crura generally well developed. A pair of auricular crura generally present.

Length 22.7 mm, height 21.2 mm, convexity (both valves) 8.2 mm (type). Length 25.7 mm, height 24 mm, convexity about 3 mm (largest specimen).

Type (articulated, but valves rotated): USNM 647128.

Type locality: 136a (Stanford University 2611, Transisthmian Highway, lat. 9°21′ N., plus 1,100 feet (335 m); long, 79°49′ W., Panamá; same as USGS 16912), lower part of Gatun formation.

Leptopecten ecnomius is an abundant and characteristic species of the lower part of the Gatun formation. It is represented by 380 specimens, about equally divided into right and left valves. The range in length is 2.2 to 25.7 mm. Six, including the type, are articulated. The species is very abundant at localities 138c and 138d (actually two collections from the same locality): almost 300 in the two collections.

Even though auricles are missing—as they are on many valves—the long, conspicuous ctenolium serves to distinguish right valves, provided the anterior margin is intact.

This species is similar to the living *L. bavayi* (Dautzenberg, 1900, p. 228, pl. 10, figs. 2, 2a; Greater Antilles, Venezuela, and southward along coast of Brasil), but is larger (length of type of *L. bavayi*, 10 mm; length of largest specimen in USNM collections, 17.8 mm), and the concentric sculpture is less scabrous. Four names have been proposed for late Miocene and Pliocene forms of *Leptopecten* from Florida. *L. ecnomius* is smaller than the form represented in Druid Wilson's large late Miocene collection from Punta Gorda (USGS 22454, length up to 29.5 mm), and its auricles are narrower. Perhaps *L. olgensis* (Mansfield, 1939, p. 51, pl. 2, figs. 1, 2, 4; proposed as *Pecten* (*Pecten?*) *wendelli olgensis*) is the name to be used for this late Miocene form. The type of *Pecten wendelli* (Tucker, 1934, p. 612, pl. 25, fig. 1) is unrecognizable.

Occurrence: Lower part of Gatun formation (middle Miocene), localities 136a, 137, 137a, 138, 138a, 138b, 138c, 138d, 138e, 138f, 138g, 138h.

Genus Argopecten Monterosato

Monterosato, Jour. conchyliologie, v. 37, p. 20, 1889.

Type (logotype), Monterosato, Jour. conchyliologie, v. 47, p. 193, 1899): *Pecten solidulus* Reeve, living, locality unknown, regarded as a synonym of *Pecten circularis* Sowerby, living, Baja California to northern Perú.

Argopecten replaces Dall's better known, but later, name *Plagioctenium*. The type species has been illustrated by Waller (1969, p. 33, pl. 1, figs. 11, 12, 14, 15).

Argopecten? species

Plate 87, figure 13

Small, right valve moderately convex, auricles of the single right valve missing or incomplete. Right valve sculptured with 17, or possibly 18, moderately high, inverted U-shaped ribs, crest arched; ribs wider than interribs. Fine concentric lamellae in interribs, for the most part weaker on ribs. Byssal notch narrow, as shown by byssal fasciole. Interior and left valve unknown.

Length 26.4 mm, height 25.5 mm, convexity about 5 mm (figured specimen).

If the single right valve from the Caraba formation, of late Oligocene age, is an *Argopecten*, it is the oldest known species. The moderate convexity and the moderate height of the ribs, however, suggest that it represents some other genus. In any event, the left valve is unknown.

Occurrence: Caraba formation (late Oligocene): locality 60.

Argopecten venezuelanus (F. and H. Hodson)

Plate 105, figures 1–3, 7

Pecten circularis venezuelanus F. and H. Hodson, Bull. Am. Paleontology, v. 13, no. 49, p. 25, pl. 14, fig. 6, pl. 15, figs. 2, 4, 5, pl. 17, fig. 1, 1927 (Miocene, Venezuela).

Moderately large, height and length subequal, valves of moderate and subequal convexity, or right valve slightly more convex than left, auricles subequal. Ribs high, inverted U-shaped, crest arched; ribs wider than interribs, moderately wider to as much as two or three times as wide, especially on right valves; 17 to 22 (generally 19 or 20) on both valves. Fine concentric lamellae in interribs, absent on crest of ribs. Radial sculpture on right anterior auricle moderately stronger to much stronger than on posterior. Radial sculpture of left auricles weak to moderately strong. Byssal notch narrow, deep. Ctenolium absent on few valves where it would be exposed. A pair of strong cardinal crura.

Length 42.3 mm, height 40.2 mm, convexity about 8 mm (larger figured specimen). Length 46.7 mm, height 45 mm, convexity about 8 mm (largest specimen).

Type: Paleontological Research Inst. 21931.

Type locality: La Vela area, Falcón, Venezuela, middle or late Miocene.

A species of *Argopecten* identified as *A. venezuelanus* is abundant in the upper member of the Alhajuela formation, represented by 67 specimens, 3 of which are articulated. They range in length from 10 to 46.7 mm. In size, sculpture of disk and auricles, and variation in width of interribs they closely resemble Venezuelan specimens, although the fossils from Panamá are consistently a little less convex.

It is suggested that *A. venezuelanus* is a predecessor of the eastern Pacific *A. circularis* (Sowerby) and its western Atlantic analog *A. gibbus* (Linné). The earliest comparable species in southeastern United States—*A. choctawhatcheensis* (Mansfield) and *A. comparilis* (Tuomey and Holmes—are of late middle and late Miocene age, respectively (Waller, 1969, p. 53, 55, fig. 6). Their relations to *A. venezuelanus* are undetermined. Both living species are larger and more convex than *A. venezuelanus*, and their right anterior auricle is less strongly sculptured.

Occurrence: Upper member of Alhajuela formation (early Miocene), localities 85, 85a. 89, 90, 90a, 91. Deposits of middle or late Miocene age, Falcón, Venezuela.

Argopecten levicostatus (Toula)

Plate 104, figures 7, 11; plate 110, figures 1, 2, 10

Pecten levicostatus Toula, K. k. Geol. Reichsanstalt Jahrb., v. 58. p. 713, pl. 26, figs. 4–6, 1909 (Miocene, Canal Zone). Brown and Pilsbry, Acad. Nat. Sci. Philadephia Proc., v. 63, p. 365, 1911 (Miocene, Canal Zone, Toula's record). Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 199 (assigned to subgenus *Chlamys*, section *Plagioctenium*), pl. 16, figs. 5–7, 1922 (Miocene, Costa Rica).

?*Pecten levicostatus* Toula, Barrios, Colombia Servicio Geol. Nac., Bol. Geol., v. 6, nos. 1–3 (Informe 1082), p. 240, pl. 4, fig. 2, 1960 (Miocene, Colombia).

Pecten circularis cornellanus F. and H. Hodson, Bull. Am. Paleontology, v. 13, no. 49, p. 26, pl. 14, fig. 2, pl. 15, figs. 3, 10, pl. 16, fig. 3 1927 (Miocene Venezuela).

?*Pecten circularis cornellanus* F. and H. Hodson, Barrios, Colombia Servicio Geol. Nac., Bol. Geol., v. 6, nos. 1–3 (Informe 1082), p. 239, pl. 4, fig. 1, 1960 (Miocene, Colombia).

Moderately small, height and length subequal, excepting a few valves on which posterior end is slightly longer than anterior and length is greater than height. Valves of strong and subequal convexity, auricles subequal. Ribs high, wider than interribs, crest generally flattened, or even bearing very shallow, median groove, exceptionally slightly inverted V-shaped; 19 to 22 (generally 20 or 21) on both valves. Fine concentric lamellae in interribs, extending across some ribs of some immature valves. Radial sculpture of right anterior auricle slightly stronger than that of posterior. Radial sculpture of left auricles moderate and subequal. Ctenolium very short, or absent. A pair of very strong cardinal crura, even on immature valves.

Length 36.6 mm, height 36.5 mm, convexity 11.2 mm (larger figured specimen). Length 37.2 mm, height 34.6 mm, convexity 10.3 mm (largest specimen, slightly inequilateral left valve).

Type: Paläontologisches Inst., Univ. Wien.

Type locality: Presumably Gatun Locks excavation, Canal Zone, middle part of Gatun formation.

The strong convexity, flat-crested or slightly grooved ribs, and very strong cardinal crura are characteristic features of the prevailing form of this moderately small *Argopecten*. It occurs in the Gatun formation: 25 valves in the middle part, one in the upper part in the eastern area, and 21 in that part in the western area. The range in length is 7.2 to 37.2 mm; none is articulated. Collections from the upper part in the western area include the few aberrant forms: three valves that are slightly inequilateral and one having ribs that are slightly inverted V-shaped. The very strong cardinal crura at mature and immature stages are shown on plates 110, figure 1, and 104, figure 11, respectively. Two valves from the Toro limestone member of the Chagres sandstone are doubtfully identified as *A. levicostatus*.

A. levicostatus is regarded as a predecessor of the living western Atlantic *A. nucleus* (Born). It is smaller than that species, which reaches a length of 50 mm on the south side of the Caribbean Sea, and the cardinal crura of immature fossils are stronger. In southeastern United States, *A. nucleus* is unknown before early Pleistocene time, and no predecessor has been recognized in that region, except a postulated predecessor for *A. gibbus* and *A. nucleus*, (Waller, 1969, p. 28, fig. 6).

Occurrence: Middle and upper parts of Gatun formation (middle Miocene). Middle part, eastern area, localities 154, 155, 155a, 155b, 159, 159d; western area locality 161c. Upper part, eastern area, locality 178; western area, localities 182, 182a, 183. Toro limestone member of Chagres sandstone (late Miocene or early Pliocene), identification doubtful, localities 192, 194. Deposits of middle Miocene age, Limón Province, Costa Rica. Urumaco formation (middle or late Miocene), Falcón, Venezuela.

Argopecten nerterus Woodring, n. sp.

Plate 123, figures 1, 2, 4

Moderately large, height and length subequal, generally slightly inequilateral, posterior end slightly longer than anterior. Convexity moderate and subequal, right anterior auricle slightly longer than posterior; left auricles subequal. Ribs generally low to very low, exceptionally of moderate height, crest arched; ribs wider than interribs or of about same width; 19 to 23 (generally 20 or 21) on both valves. Concentric sculpture generally in form of growth threads of irregular spacing and strength, extending across ribs and interribs, exceptionally on parts of some valves consisting of uniformly spaced fine lamellae. Flanks narrow, indistinctly set off from disk. Radial sculpture of right anterior auricle moderately stronger than that of posterior. Radial sculpture of left auricles moderately weak or absent. Byssal notch moderately narrow, moderately deep. Ctenolium short or absent. A pair of moderately strong cardinal crura.

Length 46 mm, height 43.6 mm, convexity 7.2 mm (type). Length 51.5 mm, height (incomplete) 45.5 mm (estimated restored height 50 mm), convexity about 5 mm (largest specimen).

Type (right valve): USNM 647131; paratype (left valve) USNM 647132.

Type and paratype locality: 188 (USGS 16946, Río Piña road, 0.9 mile (1.4 k) southwest of Gatun Dam spillway bridge, Canal Zone), Toro limestone member of Chagres sandstone.

This low-ribbed, moderately convex, generally slightly inequilateral species is abundant in the Toro limestone member of the Chagres sandstone west-southwest of Gatun Dam. The collections from localities 188 to 188e, inclusive, in that area, contain 110 valves, ranging in length from 7.8 to 51.5 mm.

None is articulated. It is rare elsewhere in the Toro and also in the Chagres proper. The ribs of five valves, one of which is illustrated (pl. 123, fig. 4.), are somewhat higher than those of the typical form, but others are more or less gradational.

Druid Wilson called my attention to his collection from Olsson's Unit A (USGS 22704, road-metal pit on Florida highway 80 west of Belle Glade), which consists of low-ribbed scallops of the size of *Argopecten nerterus;* the low-ribbed *Argopecten* from that locality were identified by Waller (1969, p. 65) as *A. gibbus.* Some are very slightly inequilateral. All are, however, slightly more convex than the fossils from Panamá and have a shallow byssal sinus and very weakly sculptured right anterior auricle.

Occurrence: Toro limestone member of Chagres sandstone (late Miocene or early Pliocene), localities 187, 188, 188a, 188b, 188c, 188d, 188e. Chagres sandstone proper (late Miocence or early Pliocene), localities 201, 202 (fragment, identification doubtful).

Subfamily?

Genus Nodipecten Dall

Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 4, p. 695, 1898.
Type (orthotype): *P*[*ecten*] *nodosus* L[inné] [*Ostrea nodosa* Linné], living, Florida to Brasil.

Group of Nodipecten magnificus

The basic differences between the group of *Nodipecten nodosus* and the group of *N. magnificus* were pointed out by Grant and Gale (1931, p. 180, 182). The left median rib of both groups is wide and strongly noded. In the group of *N. nodosus,* that rib is flanked on both sides in succession by a narrower, less strongly noded or nonnoded rib; a wide, strongly noded rib; and one or two narrower, less noded ribs. In the group of *N. magnificus,* the wide, strongly noded median rib is flanked by two narrower, less strongly noded or nonnoded ribs; a wide, strongly noded rib; two narrower, less noded ribs; and a narrow, somewhat noded rib. In both groups, the width of the corresponding right interribs at and near the ventral margin agrees more or less closely with the width of the left ribs.

The difference in width of left ribs and right interribs in the two groups may be subtle or even absent on some specimens, or on some species, but the larger number of ribs in the group of *N. magnificus* is unmistakable, although, as usual, the number is somewhat variable.

The roots of *N. magnificus,* a rare species in the tropical eastern Pacific ocean, like those of many eastern Pacific species, are in the western Atlantic part of the Tertiary Caribbean province.

Nodipecten denaius Woodring, n. sp.

Plate 92, figure 11; plate 98, figures 7, 9

Small, height little less than length, right valve more convex than left on only articulated specimen. Both valves marked by a "resting stage." Ribs inverted U-shaped, slightly undercut, except near ventral margin, wider than interribs. Fifteen nonnoded, subequal ribs on right valve; interribs subequal. Twelve ribs remaining on incomplete left valve. Left-valve ribbing of *Nodipecten magnificus* type, but on posterior side, median rib flanked by three, instead of two, weakly noded ribs. Ribs and interribs of both valves bearing radial threads, crimped by more or less distant concentric threads or growth lines. Flanks very narrow, radially sculptured. Auricles not well preserved or missing, radially sculptured where preserved. Interior not preserved or inaccessible.

Length (almost complete) 47.5 mm, height 49 mm, convexity (both valves) 16.5 mm (type).

Type (articulated): USNM 647126.

Type locality: 101g (USGS 23654, Panama Canal, west side of Las Cascadas Reach, Canal station 1767 plus 15 m, Canal Zone), upper limestone in upper part of La Boca formation.

The type (pl. 98, figs. 7, 9), from the La Boca formation, is the only unequivocally identified specimen of *Nodipecten denaius.* Though it is articulated, the valves are rotated about 15°. Two valves are doubtfully identified: one from the Caimito formation, the other from the Emperador limestone member of the La Boca in Madden basin. Both evidently are right valves. They are doubtfully identified, as the left valve is unknown. The valve from the Caimito (pl. 92, fig. 11; length 47 mm, height 44 mm) is of special interest as the oldest known reasonably preserved *Nodipecten.* Though it is not well preserved, it has 15 ribs at the ventral margin, like the right valve of the type of *N. denaius.* Only traces of radial threads and concentric sculpture are discernible on a few ribs and interribs. At the ventral margin, an interrib near the median line is slightly wider than the others. The valve is marked by two "resting stages." Only the lower posterior part of the valve from the Emperador is exposed, showing eight ribs.

N. denaius probably is a small predecessor of *N. colinensis* (F. and H. Hodson, *in* Hodson, Hodson, and Harris, 1927, p. 33, pl. 18, figs. 3, 6, pl. 19, fig. 4; length 97 mm), a late Miocene Venezuelan species. The Hodsons' illustration of a left-valve paratype (their pl. 19, fig. 4) shows to good advantage the sculpture of a species of the group of *N. magnificus.*

A small laterally crushed valve from the Panamá formation, also of late Oligocene age, is listed as *Nodipecten* sp. (height 29.5 mm).

Occurrence: Caimito formation (late Oligocene), locality 52a (identification doubtful). La Boca formation (early Miocene), Gaillard Cut area, locality 101g. Emperador limestone member of La Boca formation (early Miocene), Madden basin, locality 72 (identification doubtful).

Nodipecten clydonus Woodring, n. sp.

Plate 101, figures 5, 6

Large, height less than length, right valve more convex than left on only articulated specimen. Both valves marked by four "resting stages." Right valve sculptured with 14 high, wide, vertical-sided ribs, noded at "resting stages." Ribs wider than interribs, up to three times as wide. Left valve sculptured with 13 ribs, of about same width as interribs, noded at "resting stages," like those of right valve. Radial threads generally absent on both valves, faint where present. Concentric sculpture consisting of closely spaced undulations, conspicuous on sides and crest of some ribs and in some interribs. Flanks very narrow, concentrically sculptured, radially sculptured by narrow grooves. Right anterior auricle longer than posterior (left anterior not preserved), right anterior radially and concentrically sculptured; right and left posterior auricles concentrically sculptured. Byssal notch of moderate width and depth. Interior inaccessible.

Length 98 mm, height 88 mm, convexity (both valves) 44 mm (type).

Type (articulated): USNM 647127.

Type locality: 76 USGS 5906a, Río Chagres about 1.5 miles (2.5 k) above Alhajuela, Canal Zone; a submerged locality), lower member of Alhajuela formation.

The articulated type and three incomplete, poorly preserved valves of *Nodipecten clydonus* were found in the lower member of the Alhajuela formation. Though the left-valve ribbing is not like that of a typical species of the group of *N. magnificus*, the large number of the ribs justifies assignment to that group. Three ribs are missing on the left valve, but the count can be completed by using the corresponding right-valve interribs.

This species has no known close allies. The radial threads on ribs and interribs of other species of the genus generally are absent and are faint where present. To be sure, the crest of many ribs is worn, but the threads are absent on unworn crests. The concentric lamellae are relatively widely spaced. They are well shown in the lower anterior part of the left valve (pl. 101, fig. 5).

Occurrence: Lower member of Alhajuela formation (early Miocene), locality 76.

Family PLICATULIDAE

Genus Plicatula Lamarck

Lamarck, Systême des animaux sans vertèbres, p. 132, 1801.

Type (logotype, Schmidt, Versuch über die beste Einrichtung * * * vorzüglich der Conchylien-Sammlungen * * *. p. 61, 176, 1818 (not seen, quoted from Stewart, 1930, p. 33–35, 114, and Winckworth, Malacological Soc. London Proc., v. 26, p. 23–24, 1944): *Spondylus plicatus* Linné, living western Pacific Ocean), cited in synonymy of *Plicatula gibbosa* Lamarck.

According to Hanley (1855, p. 84), *P. plicatus* is the western Pacific species described by Sowerby (1847 p. 437, pl. 91, figs. 15–18) as *P. imbricata* Menke.

Plicatula gibbosa Lamarck, small form

Plate 124, figures 2, 3

Plicatula gibbosa Lamarck, Systême des animaux sans vertèbres, p. 132, 1801 (living). Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 4, p. 763, 1898 (Miocene(?), Jamaica, living). Maury, Bull. Am. Paleontology, v. 10, no. 42, p. 91, pl. 11, figs. 4, 5, 1925 (Pliocene, Trinidad). Weisbord Bull. Am. Paleontology, v. 45, no. 204, pl. 10, figs. 10–13, 1964 (Pliocene, Venezuela; additional citations). Warmke and Abbott, Caribbean seashells, p. 167, pl. 34, fig. g, 1961 (living, West Indies). Jung, Bull. Am. Paleontology, v. 55, no. 247, p. 436, pl. 19, figs. 1, 2, 1969 (Pliocene. Trinidad).

Plicatula vexillata Guppy, Sci. Assoc. Trinidad Proc., v. 2, p. 86, pl. 2, fig. 7, 1873; text reprint, Bull. Am. Paleontology, v. 8, no. 35, p. 70, 1921 (Miocene and Pleistocene(?), Jamaica). Guppy, Geol. Mag., n. ser., 2d decade, v. 1, p. 436, pl. 17, fig. 7, 1874 (Miocene and Pleistocene(?), Jamaica).

Plicatula densata Conrad, Dall (part), Wagner Free Inst. Sci. Trans., v. 3, pt. 4, p. 763, 1898 (Miocene, Jamaica).

Plicatula marginata Say, Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 208, pl. 28, figs. 6, 7, 1922 (Miocene, Costa Rica).

Plicatula guppyi Woodring. Carnegie Inst. Washington Pub. 366, p. 78, pl. 9, figs. 9–11, 1925 (Miocene, Jamaica).

Small, triangular ovate to ovate. Sculptured with 5 to 9 ribs (peaks at 5, 7, and 8). Widely spaced concentric lamellae generally present, especially on ventral part, extending across ribs and interribs; vaulted on ribs, vaults extended on many shells, forming low scales. Noded riblets observed in ventral part of two interribs on one valve (pl. 124, fig. 2). Hinge not preserved.

Length 14 mm, height (almost complete) 15.7 mm, convexity 4 mm (larger figured specimen, largest specimen).

Type: Unknown.

Type locality: Presumably West Indies, living.

A collection of 55 small specimens, two of which are articulated, from the Toro limestone member of the Chagres sandstone is the sole representation of the genus *Plicatula*. They are indistinguishable from immature *P. gibbosa*. Henderson dredged about 160 immature dead shells of that species, of about the same size as the fossils, at a depth of 61 fathoms off Sand Key, Fla. (USNM 450736).

The type lot of Guppy's *P. vexillata* consists of two syntypes. The larger is the specimen illustrated by Guppy and is herewith designated the lectotype. It has a fresh color pattern—the pattern of *P. gibbosa*. Dall, who recognized it as that species, was justified in suspecting that it is a Pleistocene shell. The other syntype, which has the appearance of a Bowden shell, is the type of *P. guppyi* a name that is to be suppressed as a synonym of *P. gibbosa*.

Though Miocene fossils from Costa Rica, Panamá, and Jamaica are now identified as *P. gibbosa*, all are small. The maximum height of some 170 Jamaican shells is 18.5 mm. Living shells reach a height of some 30 mm.

Occurrence: Toro limestone member of Chagres sandstone (late Miocene or early Pliocene), locality 196. Deposits of middle Miocene age, Limón Province, Costa Rica (Olsson's record). Bowden formation (middle Miocene), Jamaica. Limónes formation (late Miocene), Bocas del Toro area, Panamá (Olsson's record). Playa Grande and Mare formations (early Pliocene), Venezuela. Matura formation (early Pliocene), Trinidad. Living, southeastern United States to Uruguay.

Family SPONDYLIDAE

Genus Spondylus Linne

Linné, Systema Naturae, 10th ed., p. 690, 1758.

Type (logotype, Gray, Zool. Soc. London Proc., p. 201, 1847): *Spondylus gaderopus* [*gaederopus*] Linné, living, Mediterranean Sea and Atlantic coast of northern Africa.

Spondylus olssoni Clark

Plate 83, figures 7, 9

Spondylus olssoni Clark, *in* Clark and Durham, Geol. Soc. America Mem. 16, p. 55, pl. 3, figs. 1, 5, 6, pl. 4, figs. 1, 6, 1946 (Eocene, Colombia).

Spondylus olssoni n. subsp.(?), Clark, *in* Clark and Durham, Geol. Soc. America Mem. 16, p. 55, pl. 4, fig. 5, 1946 (Eocene, Colombia).

Moderately large, triangular-ovate, decidedly inequilateral or almost equilateral, right valve more convex than left. Sculptured with many, very narrow, closely spaced ribs, crest arched or slightly angular, except at posterior end; few ribs divided at early stage; few median ribs divided on a mature right valve. Umbonal area of right valve sculptured also with low foliaceous concentric lamellae, frilled by ribs. Lamellae exceptionally continuing, with wider spacing, over almost dorsal half of valve. Few ribs on some right and left valves bearing low vaulted scales; such ribs separated by several ribs that lack scales. At early stage of left valve, some ribs slightly stronger than others and undulated. Scalloped growth lines conspicuous, especially near ventral margin, where some are exaggerated. Auricles not completely preserved. Cardinal area of right valve dorsoventrally extended, forming, as usual, acute triangle; that of left valve not preserved.

Length 77 mm, height 88 mm, convexity 30 mm (figured almost equilateral right valve). Length 73 mm, height 92 mm, convexity 25 mm (figured decidedly inequilateral right valve, largest speciemn).

Type: Univ. California, Berkeley, 34916.

Type locality: Univ. California, Berkeley, S8049, Arroyo Mancomojancito, just above Salto, about 1 km downstream from La Puenta, Bolívar Dept., Columbia, late Eocene part of Carmen formation.

Spondylus olssoni is distinguished by the large number of very narrow, closely spaced ribs and the absence of conspicuous scales or spines. It occurs in the Gatuncillo formation, which yielded four right valves, four left, and two poorly articulated specimens. The range in height is 18 to 92 mm. The left valves are incomplete or immature. Concentric sculpture continues to a late stage on the illustrated almost equilateral right valve (pl. 83, fig. 7). At a late stage, the ribs of none of these fossils are grooved like the median ribs of a Colombian right valve shown on Clark's plate 4, figure 5. Colombian right valves lack concentric sculpture in the umbonal area, or it is inconspicuous. As noted by Palmer (1938, p. 8) such sculpture is present or absent on valves of the same species. So far as concentric lamellae are concerned, the most remarkable American fossil or living species is *S. lamellacea* (Kellum, 1926, p. 21, pl. 2, fig. 8; Eocene, North Carolina). Its greatly extended lamellae continue even on the ventral part of the valve.

The *S. olssoni* type of ribbing is shown by an unidentified species from the middle Eocene of Jamaica

(Trechmann, 1923, p. 362, pl. 18, fig. 4) and by another unidentified species from the early Eocene of Alabama (Harris, 1897, p. 42, pl. 6, fig. 11).

Pecten (*Hinnites*) *aratus* (Cooke, 1919, p. 143, pl. 12, figs. 2a, 2b, 3–7; St. Bartholomew) is a middle Eocene species of *Spondylus*, evidently the same as *Spondylus* sp. (Cooke, 1919, p. 145) from the same formation. Its ribs are fewer and wider than those of *S. olssoni*.

Occurrence: Gatuncillo formation (late Eocene), localities 11, 32. Late Eocene part of Carmen formation, Bolívar Dept., Colombia.

Spondylus scotti Brown and Pilsbry

Plate 97, figures 5, 8–10

Spondylus scotti Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 64, p. 514, pl. 25, figs. 1, 2, 1913 (Miocene, Canal Zone).

?*Spondylus bostrychites* Guppy, Cooke, Carnegie Inst. Washington Pub. 291, p. 144, pl. 11, figs. 11a, 11b, 1919 (Miocene, Anguilla).

?*Spondylus lucasi* Maury, New York Acad. Sci., Scientific Survey of Porto Rico and Virgin Islands, v. 3, p. 23, pl. 5, fig. 1, 1920 (Miocene, Puerto Rico).

Moderately large, right valve narrowly triangular-ovate to widely triangular-ovate, left valve widely triangular-ovate; moderately inequilateral to almost equilateral; right valve more convex than left. Auricles small. Ribs generally of two orders. Primary ribs generally separated by several very narrow, closely spaced ribs, as many as 12. Primary ribs bearing low vaulted scales or short spines. Very low scales on few secondary ribs of some specimens. Entire shell sculptured with more or less conspicuous fine concentric threads. Umbonal area of right valve generally sculptured also with low foliaceous concentric lamellae. Hinge of right valve, as usual, consisting of a pair of heavy isodont teeth flanking resilium pit. Interior of left valve inaccessible.

Length 52.8 mm, height 67.5 mm, convexity (both valves) 39.5 mm (figured specimen with narrowly triangular-ovate right valve). Length 67 mm, height 78.5 mm, diameter (both valves) 47 mm (figured specimen with widely triangular-ovate right valve).

Type: The articulated specimen illustrated by Brown and Pilsbry, Acad. Nat. Sci. Philadelphia 3863, now lost or misplaced.

Type locality: Lignitic bed below the "*Pecten* bed" at Tower N [Panama Canal, west side of Las Cascadas Reach], Canal Zone, La Boca formation.

Spondylus scotti occurs in the La Boca formation, including the Emperador limestone member. Eleven right valves, one left, and eight articulated specimens are available, all except four of which are from the La Boca proper. Those from localities 99, 99a, 99f, and 99g were collected in the type area, but not from the same bed as the type.

The range of variation in the outline of right valves is shown by the illustrations. A left valve (locality 100b) is even wider than the wider illustrated right valve and is almost equilateral. The ribs of the wider illustrated right valve show little differentiation as primary and secondary. The ribs of another specimen from the same locality are almost subequal and are almost as narrow as those of *S. olssoni*. A third specimen from that locality has the prevailing ribbing of *S. scotti*. The variation in outline and ribbing is so great that on a typological basis it would be supposed that several species are represented.

S. scotti is a representative of a group of species widely distributed in the late Oligocene and Miocene formations of the Caribbean region and Florida. Nine names, but not that many species, are involved. The earliest name (and the only one that antedated *S. scotti*), *S. bifrons*, was used by Sowerby (1850, p. 53) for a middle Miocene species from the Dominican Republic. As that name is a junior homonym, Guppy (1867, p. 176) published the substitute name *S. bostrychites*. This species has been found in the Gurabo formation. The lectotype and five paratypes have been described and illustrated by Palmer (1938, p. 6, pl. 1, fig. 2, pl. 2, figs. 1–3, pl. 3, figs. 1-5). *S. scotti* is smaller and has more primary ribs. Its secondary ribs are narrower, more numerous, and more closely spaced. Of the specimens of *S. scotti* in USNM collections, only that shown on plate 97, figures 5, 9, has a full complement of primary ribs: 12 or 13. The type was described as having 17.

It is not my intention to consider all the other names. As indicated by the synonymy, however, the small early Miocene *Spondylus* from Anguilla and that of the same age from Puerto Rico have the basic features of *S. scotti*. The small species from the late Oligocene of Antigua, listed by Cooke, evidently is the same as that from Anguilla, as he thought. It may be pointed out also that the large specimen, mentioned by Dall when he named *S. chipolanus* without any illustration (Dall, 1890-1903, p. 759, 1898), and described by Gardner (1926-47, p. 51, 1926), should be designated the lectotype, not the immature specimen (height 29.6 mm) illustrated later by Dall (1915, pl. 19, fig. 1). *S. chipolanus* is a member of this group from the Chipola formation of Florida. As pointed out by

Gardner, contrary to expectation, the immature specimen is from the Chipola formation, not the Tampa limestone.

Occurrence: La Boca formation (early Miocene), Gaillard Cut area, localities 99, 99a, 99f, 99g, 99h, 100b, 101b, 101e, 101h, 116a. Emperador limestone member of La Boca formation (early Miocene), Gaillard Cut area, localities 117a, 117b; Madden basin, locality 71.

Family DIMYIDAE

Genus Dimya Rouault

Rouault, Soc. Géol. France Mém., 2d ser. v. 3, p. 470, 1848.
Type (monotype): *Dimya deshayesiana* Rouault, Eocene, France.

Though only one American fossil species of *Dimya*—*D. grandis* (Dall, 1896, *in* Guppy and Dall, p. 328; Dall, 1890–1903, p. 764, pl. 35, fig. 8, 1898)—has been recorded so far, the genus is found in the La Boca and Gatun formations and is extraordinarily abundant in the La Boca.

D. grandis was based on two mature right valves and an immature left, collected about the middle 1800's by the lawyer-mining engineer-malacologist Thomas Bland, at Potrero on Río Amina in the Dominican Republic, where the middle Miocene Gurabo formation crops out. It is a large species (length 33 mm). The exterior of the right valve illustrated in interior view by Dall (herewith designated the lectotype) lacks radial sculpture, whereas the other right valve is sculptured with closely spaced radial riblets of variable width. It is Dall's casually named variety *divaricata*, a name that should be suppressed. Five other valves are in the Gabb collection from the Dominican Republic (Pilsbry, 1922, p. 413).

Dimya adaia Woodring, n. sp.

Plate 95, figures 1, 2, 4, 7, 12

Small, obliquely subovate, inequilateral, posterior end longer, right valve more convex than left. Right valve more or less smooth, except for concentric, or concentric and radial, slight undulations; or sculptured with generally weak radial riblets, except in umbonal area. Left valve marked by more or less strong growth lines or undulations; exceptionally sculptured with weak radial riblets. Minute chomata-like denticles on interior of valve near margin. Muscle scars not discernible.

Length 18.6 mm, height 17.6 mm, convexity 5 mm (type). Length 17 mm, height 19 mm, convexity 2.5 mm (paratype).

Type (right valve): USNM 647201; paratype (left valve) USNM 647202.

Type and paratype locality: 101h (USGS 23652, Panama Canal, west side of Las Cascadas Reach, Canal stations 1774 to 1778 plus 23 m, near top of canal cliff, Canal Zone), La Boca formation.

A total of 250 valves was collected from strata in the La Boca formation at two localities, 230 of them from the type locality. In that large collection, left valves outnumber right by a 4:1 ratio, whereas in the other collection, right valves are slightly more numerous than left. The range in length is 8 to 20 mm.

Dimya adaia is similar in general features to the living Caribbean *D. argentea* (Dall, 1886, p. 228, pl. 4, figs. 5a, 5b; Bayer, 1971, p. 221, figs. 68, 71B; recorded depth range 73 to 248 fathoms) and perhaps is to be identified as that species. Four valves in two of the five lots studied by Dall—the right and left valve syntypes dredged off St. Vincent, and a right and left valve dredged off the nearby Grenadines—show the "fine radiating wrinkles" extending upward from the pallial line, described by Dall (p. 229), but not shown in his interior drawing. Inasmuch as this feature is not consistent, it presumably has no taxonomic significance. In any event, it is not shown by any of the fossils on which the interior is exposed. The two Grenadines valves just mentioned have faint exterior radial sculpture, finer than that of the sculptured fossils. Nevertheless among the many unstudied lots recovered by Henderson off Barbados, two lots include valves that are as coarsely sculptured as the fossils (USNM 501351, 501381).

Occurrence: La Boca formation (early Miocene), Gaillard Cut area, localities 99f, 101h.

Dimya phaidra Woodring, n. sp.

Plate 109, figures 1, 2, 7, 8

Small, exterior lustrous, especially left valve. Obliquely subovate and inequilateral, or ovate and practically equilateral. Attachment scar forming shallow trough almost entire length of right valve. Convexity of valves subequal. Right valve sculptured with low, foliaceous concentric lamellae, slightly undulated, except near ventral and lateral margins, where they are more strongly undulated. Left valve sculptured with strong foliaceous lamellae, edges strongly crimped; umbonal area smooth. Narrow, widely spaced ridges, perpendicular to margin, outside of porcelaneous inner shell layer on anterior and posterior dorsal margins of right valve, extending almost to ventral margin on posterior side. Corresponding pits on left valve. Posterior adductor scar of left valve indistinctly bifid. Scars of right valve indistinct.

Length 9.9 mm, height 11.9 mm, convexity 1.4 mm (type). Length 6.4 mm, height 7 mm, convexity 1.5 mm (paratype).

Type (left valve): USNM 647205; paratype (right valve) USNM 647206.

Type and paratype locality 185 (USGS 8383, west of Río San Miguel [Río Miguel], station 26 plus 100 feet (30 m), Panamá), upper part of Gatun formation.

Dimya phaidra, based on a mature left valve and an immature right, is unique among American fossil and living species of the genus because of the strong and strongly crimped foliaceous lamellae of the left valve. The left valve of the Philippine species *D. filipina* (Bartsch, 1913, p. 305, pl. 28, figs. 1–4) is similarly sculptured, but the lamellae are not as strong or as strongly crimped.

Occurrence: Upper part of Gatun formation (middle Miocene), western area, locality 185.

Family ANOMIIDAE

Genus Anomia Linne

Linné, Systema naturae, 10th ed., p. 700, 1758.

Type (logotype, Schmidt, Versuch über die beste Einrichtung * * * vorzüglich der Conchylien-Sammlungen * * *, p. 177, 1818 (not seen, quoted from Stewart, 1930, p. 33–35, 65): *Anomia ephippium* Linné, living eastern North Atlantic Ocean and Mediterranean Sea.

A poorly preserved left valve from the Caimito formation on Pato Horqueto Island, and another from the La Boca formation at Las Cruces are listed as *Anomia* sp.

Anomia cf. A. lisbonensis Aldrich

Plate 85, figures 5, 7, 8

Of medium size to large, thin-shelled or thick-shelled. Left valve subcircular to ovate. Umbo high and strongly inflated or low and slightly inflated. Sculptured with weak low radial riblets, except on ventral part of mature valve. Right valve subcircular, almost flat, slightly warped, no radial sculpture apparent. Concentric lamellae more or less pronounced on both valves. Left adductor scar larger than accompanying byssal scar and more ventral in position or on same level.

Length 40 mm, height 42.5 mm, convexity about 13 mm (larger figured left valve. Length 58 mm, height 54.5 mm, convexity about 16 mm (exceptionally large left(?) valve).

Eight incomplete right valves, 10 left (not including several very small ones), for the most part incomplete, and many fragments are now in the collection from locality 23b. In addition, many valves fell apart when *Anomia*-bearing rock was soaked in water. Most of these fossils, except the large thick-shelled exfoliated left(?) valve, are very fragile, as micalike flakes readily peel off. Left valves that show the exterior to good advantage are weakly sculptured radially, but such sculpture is not apparent on right valves. Two right valves and a fragment of a third show the partly enclosed byssal foramen.

A. lisbonensis (Aldrich, 1886, p. 41, pl. 4, fig. 6; Harris, 1919, p. 17, pl. 11, figs. 6–10; middle Eocene, Alabama) basically lacks radial sculpture. Though a few of the valves examined show a trace of such sculpture, it is not as strong as that of the fossils from Panamá.

Occurrence: Gatuncillo formation (late Eocene), locality 23b.

Anomia cf. A. ephippioides Gabb

A small right valve and a smaller left were found in sandstone of the Gatuncillo formation at locality 32. The left valve is incomplete and in poor condition. Where the outer shell layer is preserved, it shows weak pustular sculpture suggesting that of *A. ephippioides* Gabb (Stenzel, Krause, and Twining, 1957, p. 98, pl. 8, figs. 3, 9, 12, pl. 9, figs. 1, 2,), a middle Eocene species from Texas. The dimensions of the right valve are as follows: length 24.5 mm, height 21 mm, convexity about 2 mm.

Occurrence: Gatuncillo formation (late Eocene), locality 32.

Anomia peruviana gabbi Pilsbry and Johnson

Plate 101, figure 4; plate 103, figures 1, 5

Anomia ephippium Linné, Gabb, Am. Philos. Soc. Trans., n. ser. v. 15, p. 1873 (Miocene, Dominican Republic).

Anomia gabbi Pilsbry and Johnson, Acad. Nat. Sci. Philadelphia Proc., v. 69, p. 193, 1917 (Miocene, Dominican Republic). Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 73, p. 409, pl. 43, fig. 1, 1922 (Miocene, Dominican Republic).

Anomia berryi Spieker, Johns Hopkins Univ. Studies in Geology, no. 3, p. 127, pl. 7, figs. 6, 7, 1922 (Miocene, Perú). Olsson, Bull. Am. Paleontology, v. 19, no. 68, pl. 3, figs. 2, 6, 1932 (Miocene Perú).

Anomia gabbi falconensis F. Hodson, *in* Hodson, Hodson, and Harris, Bull. Am. Paleontology, v. 13, no. 49, p. 42, pl. 24, fig. 1, pl. 26, figs. 1, 2, 1927 (Miocene, Venezuela).

Anomia palmasensis F. Hodson, *in* Hodson, Hodson, and Harris, Bull. Am. Paleontology, v. 13, no. 49, p. 42, pl. 24, figs. 2, 5, 6, 1927 (Miocene, Venezuela).

Anomia venezuelana Harris *in* Hodson, Hodson, and Harris, Bull. Am. Paleontology, v. 13, no. 49, p. 43, pl. 23, figs. 2, 3, pl. 26, fig. 4, 1927 (Miocene, Venezuela).

Left valve moderately large, normally broadly elliptical or subcircular, moderately to strongly convex, thin shelled or moderately thin shelled. Exceptionally assuming bizarre shapes; others exceptionally thick shelled. Generally sculptured, either with low, closely spaced radial riblets of variable width, or with strong to moderately strong radial ribs and one or more low riblets in interribs. Exceptionally smooth or almost smooth. Muscle scars not discernible. Right valve unknown.

Length 59.5 mm, height 47 mm, convexity 16 mm (largest figured specimen).

Type: Acad. Nat. Sci. Philadelphia 2642.

Type locality: Dominican Republic, Miocene.

Only left valves of this *Anomia* are available. Sixteen were collected at locality 83, and five, all of medium size or small and all smooth or practically smooth, at locality 78, both in the lower member of the Alhajuela formation. The collection from locality 83 includes four valves of bizarre shape, two of which are illustrated (pl. 103, figs. 1, 5), and two small ones that are thick-shelled. A valve of normal shape is shown on plate 101, figure 4. One valve bears the seat of a calcified byssal plug. One valve was found in the middle part of the Gatun formation.

The type is the only known specimen from the Dominican Republic. Its locality and formation are unknown. The type of *A. berryi* is exceptionally convex and is sculptured with narrow riblets, but two unidentified valves in Spieker's collections have strong ribs.

A. peruviana peruviana d'Orbigny (Olsson, 1961, p. 177, pl. 24, figs. 2, 2a–2f) ranges from Monterey, Calif., to northern Perú. It has moderate radial sculpture or is smooth, but the sculpture is not as strong as that of the most strongly sculptured fossils. A fine lot of many moderately sculptured left valves (USNM 264238) was dredged by Bartsch in Pichilinque Bay, Gulf of California.

A small incomplete valve from the upper part of the Bohio formation, sculptured with narrow radial threads is listed as *A.* cf. *A peruviana gabbi.*

Occurrence: Lower member of Alhajuela formation (early Miocence), localities 78, 83. Middle part of Gatun formation (middle Miocene), eastern area, locality 144. Miocene deposits, Dominican Republic. Middle Miocene deposits, Falcón, Venezuela. Upper part of Zorritos formation and Montera formation (middle Miocene), Perú.

Anomia simplex d'Orbigny

Plate 104, figure 5; plate 121, figures 11, 12

Anomia simplex d'Orbigny, Mollusques, in de la Sagra, Historie physique, politique, et naturelle de l'île de Cuba, v. 2, p. 867, pl. 28, figs. 31–33, 1847(?) (living Cuba and Martinique). Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 4, p. 784, 1898 (Miocene to living). Böse, Inst. Geol. México Bol. 22, p. 25, 75, pl. 2, figs. 18–33, pl. 7, fig. 5, 1906 (Miocene and Pliocene(?), México). Maury, Bull. Am. Paleontology, v. 5, no. 29, p. 191, pl. 26, fig. 15, 1917 (Miocene, Dominican Republic). Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 209, pl. 21, fig. 6, 1922 (Miocene, Costa Rica, Panamá). Maury, Bull. Am. Paleontology, v. 10, no. 42, p. 92, pl. 12, fig. 8, 1925 (Miocene and Pliocene, Trinidad). Maury, Brasil Servico Geol. y Mineral. Mon. 4, p. 267, pl. 15, fig. 1, 1925 (Miocene, Brasil). Vokes, Am. Mus. Novitates, no. 988, p. 11, 1938 (Miocene, Trinidad). Alencaster-Ibarra, Assoc. Mexicana Geól. Petroleros Bol., v. 3, p. 205, figs. 6, 7, 1951 (Miocene, México). Barrios, Colombia Servicio Geol. Nac. Bol. Geol., v. 6, nos. 1–3 (Informe 1082), p. 242, pl. 4, figs. 7, 8, 1960 (Miocene, Colombia). Jung, Bull. Am. Paleontology, v. 55, no. 247, p. 350, pl. 21, fig. 6, 1969 (Miocene and Pliocene, Trinidad).

Anomia ephippium Linné, Gabb, Acad, Nat. Sci. Philadelphia Jour. 2d ser., v. 8, p. 380, 1881 (Pliocene, Costa Rica).

?*Anomia* sp. ind., Toula, K. k. Geol. Reichsanstalt Jahrb., v. 58, p. 711, 1909 (Miocene, Canal Zone).

?*Anomia microgrammata indecisa* Guppy Ms, Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 4, p. 783, in discussion, 1898 (Miocene, Jamaica).

?*Anomia indecisa* Dall, Guppy, Woodring, Carnegie Inst. Washington Pub. 366, p. 84, pl. 10, figs. 6–9, 1925 (Miocene, Jamaica).

Of medium size or small, subcircular, broadly elliptical to triangular-ovate. Left valve generally moderately convex, exceptionally almost flat, except in umbonal area. Right valve generally almost flat, exceptionally moderately convex. Surface smooth, except for concentric growth lamellae on some valves. As shown by few left valves, adductor scar slightly smaller than accompanying byssal scar and slightly more ventral in position.

Length (practically complete) 38.2 mm, height 35 mm, convexity 11 mm (largest specimen, figured left valve from Gatun formation).

Type material: Five right valves, apparently syntypes, British Museum (Natural History) (Altena, 1971, p. 34).

Type locality: Presumably Cuba, living.

Anomia simplex occurs in the Gatun formation (but not in the upper part in the eastern area) and in the Toro limestone member of the Chagres sandstone: a total of 75 valves, all except four of which are left valves. All are of medium size or small.

This widely ranging species—widely ranging in latitude and age—is found in almost every formation of Miocene and later age from New Jersey to northern Brasil. In the Tertiary Caribbean province, the earliest occurrences are in the Thomonde formation of Haiti and the Pirabas formation of Brasil, both of late early Miocene age.

The well-named *A. microgrammata indecisa* probably is a small form of *A. simplex* (maximum length 19 mm). Of scores of valves examined, a few show barely discernible microscopic radial threads near the ventral margin. As a matter of fact, the type of the nominate subspecies (Dall, 1890–1903, p. 783, pl. 35, fig. 11, 1898; Chipola formation, Florida), which has not yet been illustrated in exterior view, likewise shows barely discernible microscopic radial threads near the ventral margin. Fourteen valves from the Chipola formation, all available to Dall and Gardner, are in USNM collections. A small, very convex left valve (length 6.3 mm) is sculptured with microscopic radial threads on all except the umbonal part of the shell (USGS locality 2564).

Occurrence: Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, localities 138d, 138e. Middle part, eastern area, localities 139b, 139g, 139h, 141, 144a, 154; western area, locality 169. Upper part, western area, locality 185. Toro limestone member of Chagres sandstone (late Miocene or Pliocene), localities 190, 191, 192, 193, 194, 195, 196. Caribbean region, late early Miocene to Pleistocene. Living, Nova Scotia to Guanabara, Brasil.

Family LIMIDAE

The representation of the family Limidae is meager.

Genus Limaria Link

Link, Beschreibung der Naturalien-Sammlung der Universität zu Rostock, p. 157, 1807.

Type (Logotype, Winckworth, Malacolog. Soc. London Proc., v. 19, p. 116. 1930): *L[imaria] inflata* [Link]=*Ostrea tuberculata* Olivi, living, Mediterranean Sea and eastern North Atlantic Ocean.

Winckworth reached the conclusion that Link's citation referred to [*Ostrea*] *inflata* Gmelin, but Gmelin cited illustrations of a different limid.

Limaria? species

Two small limids were found in the La Boca formation. They are in poor condition: incomplete and only bits of shell material, or none, remaining. The larger has a length of 16 mm and a height of 18.5 mm (estimated restored height 21 mm). The outline and type of ribbing suggest a small, probably immature, *Limaria*.

Occurrence: La Boca formation (early Miocene), Gaillard Cut area, localities 99c, 99d.

Genus Limatula Wood

Wood, Mag. Nat. History, n. ser., v. 3, p. 235, 1839.

Type (logotype, Gray, Zool. Soc. London Proc., p. 200, 1847): *Pecten subauricula* [*subauriculata*] Montagu (cited by Wood as L[ima] *Limatula subauriculata* Wood), living, eastern North Atlantic Ocean.

Limatula asymbleta Woodring, n. sp.

Plate 104, figure 6

Lima (*Mantellum*) sp., Woodring, Carnegie Inst. Washington Pub. 366, p. 80, pl. 9, figs. 14, 15, 1925 (Miocene, Jamaica).

Very small, obliquely elongate, moderately narrow. Anterior margin almost straight, posterior margin broadly rounded. Prodissoconch bulbous, strongly constricted. Ventral part of anterior slope sculptured with closely spaced microscopic radial threads. Remainder of shell, except posterior slope, showing here and there obscure, more widely spaced radial sculpture. Ligament pit long, narrow.

Length 4 mm, height 5.6 mm (type).

Type (right valve): USNM 647249.

Type locality: 138 (USGS 16909, north and south sides of Transisthmian Highway, 1.6 km northeast of Canal Zone boundary, Panamá), lower part of Gatun formation.

Limatula asymbleta is based on a right valve from the lower part of the Gatun formation. It is distinguished by the very fine sculpture on the ventral part of the anterior slope. The radial sculpture of the type species, and also of species living in western Atlantic and eastern Pacific waters, is strong.

The right valve from Bowden, Jamaica, has the same outline, but the sculpture on the ventral part of the posterior slope is less distinct. It was badly damaged after being photographed.

Occurrence: Lower part of Gatun formation (middle Miocene), locality 138. Bowden formation (middle Miocene), Jamaica.

Limatula species

A right and left valve from the upper part of the Gatun formation in the eastern area are larger and narrower than *Limatula asymbleta*, the left valve being narrower than the right. Though the complete shell of neither is preserved, faint, relatively coarse radial ribbing is apparent on the posterior slope of the left valve well above the ventral margin.

Length 5.2 mm, height 9.6 mm (right valve).

Occurrence: Upper part of Gatun formation (middle Miocene), eastern area, locality 177b.

Family GRYPHAEIDAE

Subfamily PYCNODONTEINAE

Stenzel's classification in his meticulous volume on the oysters (Stenzel, 1971) is followed. However, assignment of Pycnodonteinae to family rank might be a better arrangement. The principal link between the pycnodonteines and other gryphaeids, all of which are extinct, is the position of the adductor scar, farther from the ventral margin than it is in most other oysters. In the living pycnodonteines, the position is correlated with the passage of the intestine through the pericardium and the ventricle of the heart, instead of its passage around those organs on their dorsal side. Stenzel (1971, p. N1057–N1058) gave great weight to the implied anatomical similarity.

In the faunas under consideration, eight genera and subgenera of oysters are represented by 11 species and subspecies. Two basically Cretaceous and early Tertiary genera (*Pycnodonte* and *Gryphaeostrea*) and a basically Eocene genus (*Cubitostrea*) survived until Miocene time, as in other parts of America and in Europe.

Genus Pycnodonte Fischer de Waldheim

Fischer de Waldheim, Soc. Impér. Naturalistes de Moscou Bull., v. 8, p. 118, 1835.

Type (orthotype): *Pycnodonte radiata* Fischer de Waldheim, Late Cretaceous, Crimea.

Subgenus Crenostrea Marwick

Marwick, New Zealand Geol. Survey, Palaeontological Bull. 13, p. 61, 1931.

Type (orthotype): *Ostrea wuellerstorfi* Zittel, Oligocene, New Zealand.

Pycnodonte (Crenostrea) achanes Woodring, n. sp.

Plate 89, figures 1, 2

Large, vertically ovate, very thick shelled, massive. Left valve bearing wide to moderately wide posterior, or almost central, radial sulcus, bordered on anterior side by moderately high to very high ridge and on posterior side by low ridge. Posterior end slightly extended or not extended. Irregular concentric swellings on exterior. Despite impregnation with secondary calcite, few remnants of vesicular structure visible. Adductor scar subcircular, almost central. Ligament area and its borders not preserved or inaccessible. Right valve unknown.

Length 117 mm, height (incomplete) 147 mm (estimated restored height 175 mm), convexity 82 mm (type). Length 94 mm, height 132 mm, convexity 72 mm (paratype).

Type (left valve): USNM 647276; paratype (left valve): USNM 647277.

Type and paratype locality: 32 (USGS 17163, Río Fríjol area, Canal Zone; Río Fríjol 6 km northwest of west end of Gamboa bridge), Gatuncillo formation.

Pycnodonte achanes is based on four left valves found in sandstone of the Gatuncillo formation in the Río Fríjol area. The type, which lacks the umbonal area, is the largest and has the highest anterior ridge, whereas the paratype is practically complete. The adductor scar, practically central in anterior-posterior position and a little below the vertical midpoint, is exposed on another large valve (height 167 mm).

This species is a representative of a middle Eocene to late Oligocene Caribbean lineage. It is similar to the smaller late Oligocene *P. antiguensis* (Brown, 1913, p. 603, 614, pl. 19, fig. 7, pl. 20, figs. 1, 5, 6; Cooke, 1919, p. 128, pl. 6, figs. 1a, 1b, 2a, 2b; Antigua formation, Antigua), which has a few more or less well defined left-valve radial ribs, except on the ventral part of mature valves. Though the left valve, illustrated in interior view by Cooke (pl. 6, fig. 2b), shows no chomata, they are shown on a right valve from the same locality. The middle Eocene oyster from the island of St. Bartholomew identified by Cooke (1919, p. 129, pl. 9, fig. 1) as *Ostrea* cf. *O. trigonalis*, has a distinct posterior flange. An exceptionally massive Oligocene(?) species from Costa Rica has been described recently as *P. segurai* (Woodring, 1976).

Occurrence: Gatuncillo formation (late Eocene), locality 32.

Subgenus Pycnodonte s.s.

Pycnodonte (Pycnodonte?) species

Plate 112, figures 7, 13, 15

Of medium size, ovate, thickness of shell moderate. Right valve moderately convex, left valve almost flat, irregularly warped. Attachment area large. Exterior and interior corroded. On exterior of both valves irregularly warped, low concentric lamellae. Also on both valves here and there fine, almost microscopic, radial sculpture. Resilifer wide and high, apex not preserved, axis directed obliquely forward. Adductor scar large, orbicular-ovate, located at about middle of height. Vermicular chomata absent or not preserved. Vesicular structure conspicuous on some corroded shell layers, separated by nonvesicular layers.

Length 82.8 mm, height 73 mm, convexity (both valves) about 21 mm (figured specimen).

A right and a left valve—presumably matching valves—were collected from the upper part of the Gatun formation in the western area at locality 183. They are corroded, and much of the right valve and part of the left are missing. Strangely enough the right valve is convex and the left is almost flat. The resilifer is exceptionally wide. Though *Hyotissa haitensis* occurs throughout the Gatun formation in the eastern area, this *Pycnodonte* is the only pycnodonteine so far known in the upper part in the western area.

This species is similar to an undescribed species in Druid Wilson's collection from the middle Miocene Pungo River formation of North Carolina. It may be that species, which reaches a large size (height 155 mm). The outline of both is markedly different from that of the type species.

Occurrence: Upper part of Gatun formation (middle Miocene), western area, locality 183.

Genus Hyotissa Stenzel

Stenzel, Treatise on invertebrate paleontology, Mollusca 6, Bivalvia, pt. N, v. 3, p. N1107, 1971.

Type (orthotype): *Mytilus hyotis* Linné, living western Pacific and Indian Oceans.

"Hyotissa" tryoni (Gabb)

Plate 94, figures 7, 8

Ostrea tryoni Gabb, Acad. Nat. Sci. Philadelphia Jour., 2d ser., v. 8, p. 348, pl. 45, figs. 27, 27a, 27b, 1881 (Miocene, Costa Rica).

Moderately large, vertically ovate, moderately thick shelled. Left valve strongly convex, attachment area minute, sculptured with three subcentral smooth arched ribs, wider than interribs. Ribs fading out near ventral margin. Irregular slight warping outside ribbed area. Subdued concentric undulations only near upper shell margins. Resilifer broadly triangular. Adductor scar large, suborbicular, at midpoint of height. Immature right(?) valve moderately convex, irregularly warped. Vesicular structure not apparent on either valve. Vermicular chomata on posterior dorsal margin of immature right(?) valve.

Length 88.5 mm, height (practically complete) 107.5 mm, convexity 42 mm (figured left valve).

Type: Formerly at Acad. Nat. Sci. Philadelphia, but now missing.

Type locality: Gabb's lost Sapote [Zapote] locality on Río Reventazón, northeastern Costa Rica, deposits of early Miocene age.

A mature left valve and an immature right(?) both from the La Boca formation, are identified as "*Hyotissa*" *tryoni*. This species is by no means a typical *Hyotissa* but may be a connecting link between *Pycnodonte* and *Hyotissa*. Unfortunately the type—the only specimen from Zapote—is missing. According to Gabb's illustrations, the left valve from the La Boca resembles the left valve type in essential features. The type, however, is more circular; the ribs disappear at an earlier stage, and concentric lamellae are conspicuous on the dorsal half.

Somewhat similar species, characterized by a few ribs, are recorded at several other early and middle Miocence Caribbean localities: *Ostrea gatunensis aguaclarensis* (F. Hodson, *in* Hodson, Hodson, and Harris, 1927, p. 21, pl. 10, fig. 7, pl. 11, fig. 4, pl. 12, fig. 4; early Miocene, Venezuela); *Ostrea aguaclarensis paraguanensis* (F. Hodson, *in* Hodson and Hodson, 1931a, p. 5, pl. 4, fig. 2, pl. 5, fig. 2; early Miocene, Venezuela); *Ostrea* cf. *O. paraguanensis* (Jung, 1971, p. 169, pl. 3, figs. 1, 2; early Miocene, Carriacou); and *Ostrea* aff. *O. aguaclarensis paraguanensis* (Jung, 1965, p. 443; middle Miocene, Venezuela).

Occurrence: La Boca formation (early Miocene). Gaillard Cut area, localities 101b, 116a. Deposits of early Miocene age, northeastern Costa Rica.

Hyotissa polylopha Woodring, n. sp.

Plate 100, figures 12, 13

Of medium size, subcircular, valves moderately and subequally inflated. Both valves sculptured with many high, narrow, closely spaced ribs, some 30 at margins, some resulting from bifurcation. Ribs bearing vaulted scales or short spines. Vesicular structure not apparent. Short chomata on posterior margin of incomplete right valve. Other interior features inaccessible.

Length 84.5 mm, height 84 mm, convexity (both valves) 34 mm (type).

Type (articulated): USNM 647280.

Type locality: 117c (USGS 23660, Panama Canal, west side of Las Cascadas Reach, Canal station 1792, Canal Zone), Emperador limestone member of La Boca formation.

Hyotissa polylopha is characterized by the many, narrow, closely spaced ribs, twice as many as the highest count for the next species, *H. haitensis*. It is represented by the type and two immature specimens, all articulated and all from coralliferous limestone in the Emperador limestone member of the La Boca formation in the Gaillard Cut area, and by an incomplete right valve from the Emperador of Madden basin. Parts of both valves of the type are encrusted by branching corals and calcareous algae; the right valve is also encrusted by small oyster shells.

Occurrence: Emperador limestone member of La Boca formation, Gaillard Cut area, locality 117c; Madden basin, locality 71.

Hyotissa haitensis (Sowerby)

For illustrations see descriptions by formations (p. 608–609)

Ostrea haitensis Sowerby, Geol. Soc. London Quart. Jour., v. 6, p. 53, 1850 (Miocene, Dominican Republic). Guppy, Geol. Soc. London Quart. Jour., v. 32, p. 532, 1876 (Miocene, Dominican Republic). Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 4, p. 685, 1898 (Miocene, Dominican Republic, Florida). Maury, Bull. Am. Paleontology, v. 5, no. 29, p. 182, pl. 31, figs. 1, 2, 1917 (Miocene, Dominican Republic). Cooke, Carnegie Inst. Washington Pub. 291, p. 129, pl. 7, figs. 1, 2, pl. 8, fig. 1, 1919 (Miocene, Cuba). Sanchez Roig, Cuba Dir. Montes y Minas, Bol. Minas no. 6, pl. 23, 1920 (Miocene, Cuba). Hubbard, New York Acad. Sci., Sci. Survey Porto Rico and Virgin Islands, v. 3, pt. 2, p. 99, 1921 (Oligocene and Oligocene or Miocene, Puerto Rico). Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 73, p. 409, 1922 (Miocene, Dominican Republic). Maury, Bull. Am. Paleontology, v. 10, no. 42, p. 78, pl. 9, fig. 1, 1925 (Miocene, Trinidad). Gardner, U.S. Geol. Survey Prof. Paper 142, p. 42, 1926 (Miocene, Florida). Anderson, California Acad. Sci. Proc., 4th ser., v. 18, no. 4, p. 153, 1929 (Miocene, Colombia). Trechmann, Geol. Magazine, v. 67, no. 791, p. 210, 1930 (Pliocene, Jamaica). Tucker and Wilson, Bull. Am. Paleontology, v. 18, no. 65, p. 4, pl. 4, fig. 1, 1932 (Miocene, Florida). Trechmann, Geol. Magazine, v. 71, no. 845, p. 490, 1934 (Pliocene(?), Tobago). Butterlin, La géologie de la République d'Haiti, pl. 19, figs. 75A, 75B, 1945 (Miocene, Haïti).

Not *Ostrea haitensis* Sowerby, Joukowsky and Clerc, Soc. Physique et Hist. Nat. Genève Mem., vol. 35, pt. 2, p. 170, pl. 6, figs. 20–23, 32–35, 1906 (Miocene, Panamá).

Ostrea haitensis Sowerby?, Mansfield, Florida Geol. Survey Bull. 8, p. 55, pl. 9, fig. 1, 1932 (Miocene, Florida).

Ostrea haitensis Sowerby, variety? Hubbard, New York Acad. Sci., Sci. Survey Porto Rico and Virgin Islands, v. 3, pt. 2, p. 99, pl. 15, figs. 2, 3, 1920 (Oligocene or Miocene, Puerto Rico).

Ostrea haytensis Sowerby, Gabb, Am. Philos. Soc. Trans., n. ser., v. 15, p. 257, 1873 (Miocene, Dominican Republic).

Ostrea (Lopha) haitensis Sowerby, Olsson, Bull. Am. Paleontology, v. 19, no. 68, p. 79, pl. 3, fig. 3, 1932 (Miocene, Perú). Pflug, Acta Humboldtiana, ser. Geol. Paleont., no. 1, p. 75, pl. 23, figs. 2–6, 1961 (Miocene, Dominican Republic).

Pycnodonta haitensis (Sowerby), Olsson and Petit, Bull. Am. Paleontology, v. 47, no. 217, p. 531, pl. 78, figs. 7, 7a, 1964 (Miocene, Florida). Santos and Ferreira, Brasil Div. Geologia e Mineralogia Notas Prelim. e Estudos no. 131, p. 8, pl. 2, figs. 1a, 1b, pl. 3, figs. 1a, 1b, 2a, 2b, 1966 (Miocene, Brasil).

Ostrea aff. *vespertina* Conrad, Toula, K. k. Geol. Reichsanstalt Jahrb., v. 58, p. 710, pl. 26, fig. 1, pl. 28, figs. 14, 14a, 14b, 1909 (Miocene, Canal Zone).

Ostera gatunensis Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 63, p. 366, pl. 29, figs. 1, 2, 1911 (Miocene, Canal Zone). Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 64, p. 503 (list), 1913 (Miocene, Canal Zone).

Ostrea tamiamiensis Mansfield, U. S. Geol. Survey Prof. Paper 170–D, p. 46, pl. 14, figs. 1, 3, 1932 (Miocene, Florida).

Ostrea tamiamiensis monroensis Mansfield, U. S. Geol. Survey Prof. Paper 170–D, p. 46, pl. 14, fig. 2, pl. 15, figs. 1–4, 1932 (Miocene, Florida).

Ostrea sp., Toula, K. k. Geol. Reichsanstalt Jahrb., v. 61, p. 493, 1911 (Miocene, Canal Zone).

?*Ostrea* sp. ind., Toula, K. k. Geol. Reichsanstalt Jahrb., v. 58, p. 710, 1909 (Miocene, Canal Zone).

Ostrea (Lopha) sp., Marks, Bull. Am. Paleontology, v. 33, no. 139, p. 59, pl. 2, figs. 7, 9, 1951 (Miocene, Eucador).

Specimens from La Boca formation, plate 98, figure 2.—Small to of medium size, subcircular to vertically ovate, moderately thick shelled. Left valve generally more convex than right, right exceptionally almost flat. Both valves sculptured with 5 to 17 ribs, crest generally arched, exceptionally angular. Concentric lamellae forming vaulted scales on ribs. Ligament area inaccessible, except on two immature right valves. Adductor scar of same right valves suborbicular, posterior, at about midpoint of height. Elongate chomata on same right valves and vesicular structure shown on interior of one of them. Based on 20 specimens, two of which are articulated. Largest, length 62.5 mm, height 62 mm, convexity (both valves) 39 mm (pl. 98, fig. 2).

Specimens from lower member of Alhajuela formation, plate 103, figure 7; plate 105, figures 10, 11.—Moderately large to large, subcircular to vertically ovate. Left valve slightly to strongly convex, moderately to very thick shelled. Sculptured with 7 to 10 low to moderately high ribs, crest arched, extending to ventral margin or fading out on ventral fourth of shell. Concentric lamellae forming scattered vaulted scales on ribs. Right valve slightly to strongly convex, thickness moderate. Low ribs present or absent. Concentric lamellae undulated. Resilifer of variable height and length. Muscle scar suborbicular, subcentral to somewhat posterior, little below midpoint of height. Elongate or vermicular chomata generally present. Vesicular structure shown in small corroded patches on exterior of figured left valve (pl. 103, fig. 7). Based on 14 specimens, three of which are articulated. Largest, length and height 120 mm, convexity about 20 mm.

Specimens from Gatun formation, plate 109, figures 6, 9–12.—Of medium size to moderately large, subcircular to vertically ovate, thin shelled or moderately thick shelled. Left valve generally more convex than right, exceptionally almost flat. Both valves sculptured with 6 to 17 generally high ribs, crest arched, generally extending to ventral margin, exceptionally almost disappearing on ventral fourth of shell. Concentric lamellae forming vaulted scales and exceptionally hollow spines on ribs. Resilifer moderately high and long. Adductor scar suborbicular, slightly to distinctly posterior, at or slightly below midpoint of height. Vermicular chomata generally present. Vesicular structure shown on several valves, generally in corroded patches. Based on 68 specimens, 5 of which are articulated and 37 of which are small or minute. Largest, length 93.5 mm, height 97.5 mm, convexity (both valves) 32 mm.

Specimens from Toro limestone member of Chagres sandstone.—Large, subcircular to vertically ovate, thickness of shell moderate. Right valve more convex than left. Both valves sculptured with a few (apparently not more than five or six) low wide ribs, crest arched. Few indications of vaulted scales formed by concentric lamellae. Resilifer moderately high and long. Adductor scar suborbicular, distinctly posterior, little below or above midpoint of height. Weak elongate chomata. Vesicular structure not apparent. Based on four poorly preserved valves. Largest, length and height 105 mm, convexity about 15 mm.

Species as a whole.—Type: British Museum (Natural History), LL11353.

Type locality: Valley of Río Yaque del Norte, Dominican Republic, Miocene, presumably Gurabo formation.

This widespread species is variable as it occurs in the Canal Zone—variable in outline, convexity, number of ribs, height of ribs, and configuration of their crest. The best preservation in the La Boca is found in the sample of 16 specimens from locality 101h. They range in length from 7 to 62.5 mm. The illustrated articulated specimen from that locality (pl. 98, fig. 2) is the only one in all the Canal Zone formations that has angular ribs, except in the dorsal areas. None of the fossils from the La Boca is large. The smallest number of ribs, aside from some immature valves from the La Boca and Gatun, and the lowest ribs are those on valves from the Alhajuela and Toro; in fact, the illustrated right valve from the Alhajeula (pl. 105, figs. 10, 11) has irregular, very low undulations instead of ribs. The collection from the middle part of the Gatun at locality 138b consists of nine minute right valves on one of which the prodissoconch is preserved (length 0.45 mm, height 0.4 mm).

Only one valve, illustrated by Pflug, is now in the Heneken collection. Until it can be demonstrated that Sowerby had more than one, it is the type, not a lectotype as designated by Pflug. The very short anterior end is unusual, although it is shown by the paratype of *Ostrea tamiamiensis monroensis* (Mansfield, 1932a, p. 46, pl. 14, fig. 2). In the valley of Río Yaque del Norte, *Hyotissa haitensis* is known to occur in the Gurabo formation. A fine large subcircular left valve from that formation measures 172 mm in length and 158 mm in height (USGS 8535). The age range in the Tertiary Caribbean province is late Oligocene to late Miocene, and evidently extends to Pleistocene. In southeastern United States, the range is early to late Miocene.

H. haitensis is larger than *Ostrea "thomasi"* (McLean, 1941, p. 7, pls. 3, 4; not *Ostrea sellaeformis thomasii* Glenn, 1904), living in the western Atlantic Ocean, but is smaller than *Ostrea fisheri* (Dall, 1914b, p. 1; substitute name for *Ostrea jacobaea* Rochebrune, 1895, not *Ostrea jacobaea* Linné, 1758), living in the eastern Pacific Ocean. To what extent, however, size alone can be used to distinguish species in this genus is questionable.

Ranson, who deserves much credit for recognizing, in a series of papers beginning in 1941 (Ranson, 1941), the pycnodonteine affinities of the oysters now assigned to *Hyotissa,* advocated using one name for those living in the Pacific, Indian, and Atlantic Oceans: *Pycnodonta hyotis* in his terminology. He advocated also using one name for those of Miocene age: *Pycnodonta squarrosa* (de Serres) (1843, p. 160, pl. 3, figs. 4, 4a; Miocene, southern France). There is much to be said for an extensive distribution of a euhaline oyster, especially in Miocene seas, but inasmuch as no specimens of de Serres' species are available, the name *Hyotissa haitensis* is retained. *Ostrea hyotis* has been recorded from Clipperton Island (Hertlein and Allison, 1966, p. 139), some 1,200 k southwest of Acapulco, México, but the features that distinguish the Clipperton Island oyster from *Ostrea fisheri* were not specified. Perhaps these two alleged species are indistinguishable, as Ranson claimed.

Occurrence: La Boca formation (early Miocene), Gaillard Cut area, localities 99d (identification doubtful), 99f, 99g, 101a (identification doubtful) 101h. Lower member of Alhajuela formation (early Miocene), locality 76. Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, localities 138c, 138d, 138f. Middle part, eastern area, localities 139b, 139c, 139e, 139f, 141, 143, 154, 155, 155a, 155b, 159b. Upper part, eastern area, localities 175, 175b. Toro limestone member of Chagres sandstone (late Miocene or early Pliocene), locality 189. Lares limestone (late Oligocene) and Cibao formation (possibly early Miocene part), Puerto Rico. Deposits of early and middle Miocene age, Cuba. Thomonde formation (early Miocene), Haiti. Deposits of early (?) Miocene age, Azua Province, Dominican Republic (USGS 8590). Lower member of Ponce limestone (early Miocene), Puerto Rico. Chipola formation (early Miocene), Florida. August Town formation (middle Miocene), Jamaica. Las Cahobas formation (middle(?) Miocene), Haiti, Port-au-Prince formation (middle Miocene), Haiti. Gurabo formation (middle Miocene), Dominican Republic. Limestone of middle(?) Miocene age, Bayano basin, Panamá (USGS 23667). Piojó and Tubará formations (middle Miocene), Atlántico Dept., Colombia. Shoal River formation and its Oak Grove sand member (middle Miocene), Florida. Deposits of late Miocene age, Tehuantepec area, México (USGS 13089). Daule formation (middle Miocene), Ecuador. Limónes formation (late Miocene), Limón Province, Costa Rica (USGS 21036), and Bocas del Toro area, Panamá (USGS 8318). Savaneta glauconitic sandstone member of Springvale formation (late Miocene), Trinidad. Manchioneal formation (Pleistocene), Jamacia. Deposits of probable Pliocene age, Tobago.

Subfamily EXOGYRINAE

Genus Gryphaeostrea Conrad

Conrad, Am. Jour. Conchology, v. 1, p. 15, 1865 (*Gryphoeostrea* on p. 15 corrected to *Gryphaeostrea* on unnumbered page opposite p. 190 of same volume).

Type (monotype): *O[strea] subeversa* C[*onrad*], [Eocene, now Paleocene], U[pper] Marlboro, Maryland, a nude name validated by Dall, Wagner Free Inst. Sci., Trans., v. 3, pt. 4, p. 672, 1898.

Though Dall did not describe the type species, he diagnosed the essential features of *Gryphaeostrea*, which is sufficient to validate the name of the monotype (Opinion 43 of International Commission on Zoological Nomenclature). What Dall added after the name of the monotype is irrelevant. The type lot of *Ostrea subeversa* is at the Philadelphia Academy of Natural Sciences, cataloged as 30714 (Moore, 1962, p. 99). Stenzel (1947, p. 175) reached the conclusion that the monotype is the Paleocene European species *Ostrea eversa* Deshayes, but that is a strained interpretation. No matter how this legalistic matter is settled, the effect is the same.

Gryphaeostrea species

Plate 94, figure 4

Right valve small, vertically ovate, ratio of length to height variable, almost flat. Umbo strongly opisthogyrate. Sculptured with 8 to 10 sharply crested lamellae, edge upturned. Lamellae widely spaced, except earliest. Resilifer shallow, low, wide. Suggestion of worm chrata. Adductor scar not discernible. Left valve unknown.

Length 9.8 mm, height 12 mm (figured specimen). Length 11.5 mm, height (incomplete) 14.7 mm (estimated restored height 17 mm) (largest specimen).

The large collection from the La Boca formation at locality 101h includes six right valves of an unnamed *Gryphaeostrea*. Though right valves of the genus are unmistakeable, many are indistinguishable no matter whether they are of Cretaceous, Paleocene, Eocene, Oligocene, or Miocene age.

This is the first record of a Miocene American species. Through the kindness of my colleague Druid Wilson, another early Miocene American occurrence can be recorded in a collection from the Trent marl (of former usage) of North Carolina (USGS 25346). Miocene records in Europe and Africa were listed by Stenzel (1971, p. N1125). In America, the gap between Eocene and Miocene is filled by collections from the Cooper marl of South Carolina (Richards and Hopkins, 1960, p. 21, pl. 2, fig. 4) and the Marianna limestone of Mississippi (MacNeil, *in* Malde, 1959, p. 20), both of Oligocene age.

Occurrence: La Boca formation (early Miocene), Gaillard Cut area, locality 101h.

Family OSTREIDAE

Subfamily OSTREINAE

Genus Crassostrea Sacco

Sacco, I molluschi dei terreni terziarii del Piemonte e della Liguria, pt. 23, p. 15, 1897.

Type (orthotype): *C[rassostrea] virginiana* (Gmel[in]) (*Ostrea virginica* Gmelin), living, Gulf of St. Lawrence to Gulf of Mexico.

Unidentified oysters from the Gatuncillo formation and Emperador limestone member of the La Boca formation are listed as *Crassostrea*? sp.

Crassostrea cahobasensis (Pilsbry and Brown)

Plate 90, figure 21; plate 93, figures 6, 7, 9–11; plate 94, figures 1, 3, 5; plate 102, figures 1, 5; plate 103, figure 8; plate 106, figures 2, 6, 7.

?*Ostrea* sp., Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 62, p. 489, 1910 (Miocene, Haiti).

Ostrea cahobasensis Pilsbry and Brown, Acad. Nat. Sci. Philadelphia Proc., v. 69, p. 40, pl. 6, fig. 8, 1917 (Miocene, Haiti). Maury, New York Acad. Sci., Sci. Survey Porto Rico and Virgin Islands, v. 3, pt. 1, p. 15, 1920 (Miocene, Puerto Rico) Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 73, p. 409, 1922 (Miocene, Dominican Republic).

?*Ostrea cahobasensis portoricana* Hubbard, New York Acad. Sci., Sci. Survey Porto Rico and Virgin Islands, v. 3, pt. 2, p. 102, pl. 16, fig. 1, pl. 17, fig. 1, 1920 (Miocene, Puerto Rico; not to be confused with *Ostrea sellaeformis portoricoensis* on preceding page).

Of medium size to large. Left valve narrowly to widely vertically ovate, strongly convex, irregularly warped, moderately to very thick shelled, concentric growth lamellae very irregular in strength and spacing. Right valve almost flat to moderately convex, or moderately convexly bent, generally vertically ovate, exceptionally spatulate or subspatulate, generally moderately thick shelled, exceptionally very thick shelled, concentric growth lamellae more or less uniform in strength and spacing, or almost absent on some small valves. Umbonal cavity on left valve; resilifer shallow. Resilifer of right valve moderately to strongly convex. Chomata generally absent, but present on 20 percent of valves from Culebra formation and 15 percent of those from La Boca formation. Adductor scar reniform, dorsal posterior margin slightly concave, posterior dorsal end generally pointed, located close to posterior valve margin, well below or far below midpoint of height.

Length 100 mm, height 143 mm, convexity 70 mm (largest figured left valve). Length 99 mm, height 153 mm, convexity 35 mm (largest figured right valve).

Type material: Lectotype, herewith designated, left valve figured by Pilsbry and Brown, Acad. Nat. Sci. Phila. 1308.

Type locality: Trail to Las Cahobas, Haiti, Las Cahobas formation.

The distribution of *Crassostrea cahobasensis* in Canal Zone formations, ranging in age from late Oligocene to middle Miocene, and the dimensions of the largest specimens are shown in the following table. The numbers do not include some 20 left valves attached to larger valves but do include three attache valves that show chomata.

As is apparent from the table, the largest specimen was recovered from the lower member of the Alhajuela. The only right valve from the Bohio is spatulate (pl. 90, fig. 21). Though a right-valve ovate outline is prevalent in the Culebra (pl. 93, fig. 10, pl. 94, figs. 1, 5), a few right valves from that formation are spatulate or subspatulate (pl. 93, fig. 9). No spatulate right valves were found in the other formations, although the samples are smaller than that for the Culebra. A concave right-valve posterior margin is shown only by an illustrated valve from the Alhajuela (pl. 102, fig. 5). It was paired with a left valve of similar outline, the exterior of which is disfigured by three attached valves of fair size. Left valves (pl. 102, fig. 1) are uniform in their strong convexity, nonuniform irregular warping, and irregularity of growth lamellae. The oysters from the La Boca are so similar to those from the Culebra, aside from the absence of spatulate right valves, that no illustrations are presented for the La Boca.

The exterior of a right valve from the Culebra (height 51 mm) is almost completely covered with spat (height about 5 to 10 mm) and a few patches of Bryozoa, the interior, with a few spat and many patches of Bryozoa. Another right valve from the Culebra shows traces of fine radial ribbing, most apparent near the upper lateral margins. The animal inhabiting the exceptionally large, thick-shelled right valve (height 165 mm) from the La Boca lived longer than its associates, the largest of which has a height of about 90 mm. The exterior of the exceptionally large valve is almost completely covered with attached valves of fair size, and the anterior part of the interior is similarly covered—a total of at least 13 valves. Locality 167 is the only locality in the Gatun formation that yielded euryhaline oysters. At 34 other localities, euhaline oysters were collected; at least their associates are euhaline. Most of the valves from locality 167, including those illustrated, are somewhat worn.

It would be unrealistic to suppose that the chomata-bearing valves represent a different species, much less a different genus. Wherever they were

Distribution of Crassostrea cahobasensis *and dimensions of largest specimens*

Age	Formation	Number of specimens						Dimensions of largest specimens (in mm)		
		Right valves		Left valves		Articulated	Total	Length	Height	Valve
		No chomata	Chomata	No chomata	Chomata					
Middle Miocene	Middle part of Gatun.	5	-	7	-	-	12	83	130	left.
Early Miocene	Lower member of Alhajuela.	8	-	5	-	1	14	145	195	left.
Early Miocene	La Boca	22	4	6	1	1	34	90	165	right.
Early Miocene	Culebra	54	10	11	7	-	71	81	175	left.
Late Oligocene	Bohio	1	-	2	-	-	3	53	93	right.

found, they are associated with valves that lack chomata. Three chomata-bearing valves are attached to the exterior of a right valve that lacks chomata (locality 103, Culebra formation). Aside from the chomata, the two sets of valves are indistinguishable. A chomata-bearing left and right valve from the Culebra are illustrated (pl. 94, figs. 3, 5, respectively). The valves in the type lot and others from the type region lack chomata. Some Puerto Rican valves also show chomata. *Ostrea vaughani insularis* (Pilsbry and Brown, 1917, p. 40, pl. 6, figs. 1, 1a) probably is a Dominican Republic chomata-bearing form of *C. cahobasensis.*

Occurrence: Bohio formation (late Oligocene), localities 42a, 42f. Culebra formation (early Miocene), localities 103, 104, 104a, 104b, 105, 110. La Boca formation (early Miocene), Gaillard Cut area, localities 113, 114, 115b, 116, 116a. Lower member of Alhajuela formation (early Miocene), localities 74, 83. Middle part of Gatun formation (middle Miocene), western area, locality 167. Lares limestone (late Oligocene), Puerto Rico. Late Oligocene part of Cibao formation, Puerto Rico. Thomonde formation (early Miocene), Haiti. Aguada limestone and lower member of Ponce limestone (middle Miocene), Puerto Rico. Las Cahobas formation (middle(?) Miocene), Haiti. Miocene, Dominican Republic (Pilsbry's record).

Genus Ostrea Linne

Linné, Systema naturae, 10th ed., p. 696, 1758.

Type (Internat. Comm. Zoological Nomenclature, Opinion 94, 1926): *Ostrea edulis* Linné, living, eastern North Atlantic Ocean and Mediterranean Sea.

Ostrea equestris heothina Woodring, n. subsp.

Plate 110, figures 4–9

?*Ostrea raveneliana* Tuomey and Holmes, Perrilliat Montoya, Paleontología Mexicana, no. 14, p. 9, pl. 2, figs. 7, 8, 1963 (Miocene, México).

Outline and convexity variable. Generally ovate; exceptionally narrow and somewhat arcuate. Left valve generally more convex than right, attachment area generally large for size of shell. Generally sculptured with 9 to 12 radial ribs, crest arched; ribs narrower than interribs to wider than interribs. Concentric growth lamellae of variable strength and spacing, some forming low vaulted scales on ribs of some valves. Ribs replaced by irregular warping on some immature valves. Right valve generally slightly convex, exceptionally very convex; some slightly warped. Radial ribs absent except on a small valve, marked beyond umbonal area by low, narrow riblets of same width as chomata ridges, and on lateral margins continuous with chomata ridges. Concentric growth lamellae inconspicuous. Resilifer narrow to moderately narrow. Chomata present for variable distance. Adductor scar reniform, upper end pointed, long axis oblique to valve-length axis, located close to posterior margin and at about midpoint of height.

Length 25 mm, height 30.5 mm, convexity 6.3 mm (type). Length 35 mm, height 36.4, convexity 4 mm (largest specimen, a right valve).

Type (left valve): USNM 647298; paratype (right valve) USNM 647299.

Type and paratype locality: 144a (USGS 6029b, Panama Railroad, big cut one-quarter to one-half mile (0.6 to 0.8 km) northeast of Camp Cotton [Totten], Canal Zone), middle part of Gatun formation.

This small oyster is widespread in the middle part of the Gatun formation (106 valves) and occurs also in the upper part (18 valves). The largest collection, consisting of 19 left valves and seven right is from the type locality on the Panama Railroad. The large number of left valves in that collection is noteworthy. The exceptionally sculptured small right valve, mentioned in the description, is in that collection. On another right valve (locality 140), the chomata ridges extend across almost the entire thickness of the valve. Small and minute right valves are common. Prodissoconchs are preserved on three minute right valves from locality 147b and on a right and a left from locality 155c. They have an average length of 0.4 mm and an average height of 0.45 mm.

Ostrea equestris heothina is regarded as a small predecessor of *O. equestris equestris* Say (Galtsoff and Merrill, 1962), a living euhaline oyster, the range of which includes Caribbean waters. Though specimens of the living oyster that grew under crowded conditions are scarcely larger than the fossils from the Gatun, a height range of 35 to 70 mm is not unusual, and Galtsoff and Merrill (1962, p. 243) recorded a maximum of 82 mm. No reason is apparent to suppose that the fossils grew under crowded conditions. As a fossil, the nominate subspecies is unknown before the Pleistocene.

The right valve (height 28.7 mm) from Tehuantepec, identified as *O. raveneliana*, suggests the same taxon as the fossils from the Gatun. *O. raveneliana* is a fairly large (height 80 mm) late Miocene species from South Carolina.

Occurrence: Middle and upper parts of Gatun formation (middle Miocene). Middle part, eastern area, localities 140, 141, 142, 144a, 144d, 147a, 147b, 147e, 147f, 147g, 147j, 151, 153, 154, 155c; western area, localities 161, 169. Upper part, eastern area, localities 171, 176a; western area, locality 185. Agueguexquite formation (middle Miocene), Tehuantepec area, México (identification doubtful).

Genus Cubitostrea Sacco

Sacco, I molluschi dei terreni terziarii del Piemonte e della Liguria, pt. 23, p. 12, 1897.

Type (orthotype): *C[ubitostrea] cubitus* (Desh[ayes] (*Ostrea cubitus* Deshayes), Eocene, Paris basin.

Cubitostrea? species

Four incomplete, poorly preserved valves from the Gatuncillo formation are doubtfully assigned to *Cubitostrea*. A right valve has the moderate convexity and the closely spaced, closely appressed concentric lamellae of right valves of that genus. Three of the valves that show the apical part of the interior bear chomata. The dimensions of the right valve mentioned are as follows: length (almost complete) 39.5 mm, height (incomplete) 53 mm (estimated restored height 65 mm), convexity 18 mm.

Occurrence: Gatuncillo formation (late Eocene), locality 11.

Cubitostrea rugifera (Dall)

Plate 95, figures 3, 5, 8, 11

Ostrea sellaeformis rugifera Dall, Wagner, Free Inst. Sci. Trans., v. 3, pt. 4, p. 678, 1898 (Miocene, Florida).

Ostrea rugifera Dall, Gardner, U. S. Geol. Survey Prof. Paper 142, p. 41, pl. 10, figs. 1, 2, 1926 (Miocene, Florida). Cooke and Mossam, Florida Geol. Survey, 20th Annual Report, pl. 10, figs. 1, 2, 1929 (Miocene, Florida). Cooke, Florida Geol. Survey, Geol. Bull. 29, pl. 18, figs. 1, 2, 1945 (Miocene, Florida).

Ostrea sellaeformis portoricoensis Hubbard, New York Acad. Sci., Scientific Survey Porto Rico and Virgin Islands, v. 3, pt. 2, p. 101, pl. 13, figs. 4–6, 1920 (Oligocene and Miocene, Puerto Rico).

Of medium size. Incomplete left valve vertically ovate, moderately convex, sculptured with narrow, closely spaced ribs, crest arched. Right valve vertically ovate, moderately convex, largest slightly warped; posterior margin rounded or slightly concave. Concentric lamellae closely spaced and closely appressed. Resilifer narrow. Chomata present; chomata ridges extending across entire thickness of valve on anterior margin of largest right valve. Adductor scar reniform, close to posterior margin of valve, below midpoint of height.

Length 47.2 mm, height 46.4 mm, convexity 10 mm (larger figured right valve).

Type material: Lectotype, herewith designated, left valve figured by Gardner, USNM 114570; lectoparatype, right valve figured by Gardner, USNM 114571.

Type locality: USGS 2211, Lower bed at Alum Bluff, Apalachicola River, Liberty County, Fla., Chipola formation.

Six right valves, an incomplete small left, and a fragment of another small left, all from the La Boca formation in the Las Cascadas Reach area, are identified as *Cubitostrea rugifera*. Perhaps all, except possibly the largest (pl. 95, figs. 8, 11), are immature.

At a left-valve height of 51.4 mm, the left valve of an articulated topotype (USNM 114826) extends 8.8 mm beyond the right valve—a feature common in the genus *Cubitostrea* (Stenzel, 1971, fig. J17, p. N978).

Puerto Rican specimens of both late Oligocene and early Miocene age closely resemble specimens from the Chipola formation. As indicated by Mansfield (1937, p. 203), the valves from the Tampa limestone of Florida, identified by Dall (1915, p. 123) as *C. rugifera*, are too small for satisfactory identification.

Occurrence: La Boca formation (early Miocene), Gaillard Cut area, localities 101a, 101b, 101c, 101h. San Sebastián formation, Lares limestone (both late Oligocene), early Miocene part of Cibao formation, and Aguada limestone (early Miocene), Puerto Rico. Chipola and Hawthorn formations (both early Miocene), Florida.

Subfamily LOPHINAE

Genus Lopha Roding

Röding, Museum Boltenianum, p. 168, 1798.

Type (logotype, Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 4, p. 672, 1898): *Ostrea cristagalli* Linné [*Mytilus cristagalli* Linné, cited by Röding as of Gmelin], living, western Pacific Ocean.

Lopha frons (Linne)

Plate 109, figures 3–5

Mytilus frons Linné, Systema naturae, 10th ed., p. 704, 1758 (living, West Indies).

Ostrea frons (Linné), Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 73, p. 409, 1922 (Miocene, Dominican Republic).

Ostrea (Ostrea) frons (Linné), McLean, Acad. Nat. Sci. Philadelphia, Notula Naturae, no. 67, p. 7, pl. 2, figs. 11–14 (assigned to section *Lopha*), 1941 (living, Florida and West Indies).

Ostrea (Lopha) folioides Woodring, Carnegie Inst. Washington Pub. 366, p. 61, pl. 7, figs. 3–5, 1925 (Miocene, Jamaica).

Ostrea (Lopha) cf. *folioides* Woodring, Trechmann, Geol. Magazine, v. 67, no. 791, p. 210, pl. 12, fig. 5, 1930 (Pleistocene, Jamaica).

?*Ostrea frons* or *O. (Lopha) guppyi* Woodring, Trechmann, Geol. Magazine, v. 71, no. 845, p. 491 (list), 1934 (Pliocene(?), Tobago).

Small, narrowly elliptical, moderately convex. Almost smooth arched ridge, or more irregularly swollen area, extending down median third or more of right valve: xenomorphs of left-valve substrate. Ridge or swollen area flanked by radial ribs, wider on anterior side than on posterior, or of about same width. Interior margins sparsely tuberculate; some tubercles on one valve replaced by chomata ridges. Adductor scar large for size of shell, reniform, close to posterior valve margin, slightly above midpoint of height. Left valve unknown.

Length 20.5 mm, height 36 mm, convexity 7.8 mm (larger figured right valve, largest valve).

Type: unknown.

Type locality: Presumably West Indies.

The Gatun formation yielded four right valves of this species, still living in the Caribbean region. Representatives from the Bowden formation of Jamaica were mistakenly described as a new species.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, locality 138c. Middle part, western area, locality 160a. Bowden formation (middle Miocene), Jamaica. Miocene, Dominican Republic (Pilsbry's record). Manchioneal formation (Pleistocene), Jamaica. Living, north coast of Gulf of Mexico, Florida to northeastern Brasil.

Family UNIONIDAE?

Genus?

Plate 96, figure 4

Exterior of internal molds of articulated valves, unhinged and spread apart. Moderately inequilateral, umbos full, margins incomplete. Patches of thin innermost shell material, faintly nacreous here and there.

Length (incomplete) 33.5 mm (estimated restored length 42 mm), height (probably practically complete) 29.5 mm, convexity about 10 mm (figured right valve).

This fresh-water mussel was picked up loose on the outcrop of the Cucaracha formation near the foot of Cerro Escobar, on the west bank of the Cucaracha Reach of the canal. Though it was found on the outcrop of carbonaceous shale containing coprolites, it may have been derived from a higher level. Nevertheless, the Cucaracha is the only formation on this slope of Cerro Escobar facing the canal. Part of the calcareous concretion that encased the valves backs them, and some of it was preserved in part of the space between the umbos.

Though this fossil is unidentifiable, it establishes the presence of a fresh-water mussel, as well as fresh-water gastropods (P 306–B, p. 157), in the Cucaracha.

Occurrence: Cucaracha formation (early Miocene), locality 122c.

Family LUCINIDAE

Subfamily LUCININAE

The generic order in the following account is more or less adapted from that of Bretsky (1976).

Genus Phacoides Gray

Gray, Zool. Soc. London Proc., p. 195, 1847.

Type (orthotype): *Ven[us] jamaicensis [Chemnitz]=Tellina pectinata* Gmelin, living, Florida and Gulf of Mexico to Santa Catarina, Brasil.

Phacoides cerma Woodring, n. sp.

Plate 92, figures 13–15

Small, thin-shelled, subcircular, height generally slightly less than length, moderately convex. Posterior area sharply depressed; anterior area narrow, depressed. Lunule short and deeply impressed on both valves. Concentric lamellae low, widely spaced for size of shell, except in umbonal area. Hinge not exposed, but enough of it was dug out on right valve to show anterior lateral tooth.

Length (not quite complete) 20 mm, height (not quite complete) 20.6 mm, convexity about 4 mm (type).

Type (right valve): USNM 647316.

Type locality: 54h (USGS 18841, Barro Colorado Island, western part of island, mouth of first stream north of Zetek House, Canal Zone), Caimito formation.

This small, thin-shelled species is the earliest and smallest *Phacoides* so far known in the Caribbean region. Thirteen valves and a small articulated specimen were collected in the moderately deep water facies of the Caimito formation on Barro Colorado Island.

A somewhat larger, thick-shelled worn valve from the shallow-water facies of the Caimito on Pato Horqueto Island is listed as *Phacoides* sp.

Occurrence: Caimito formation (late Oligocene), localities 54h 54k, 54m.

Phacoides cf. P. pectinata domingensis Dall

Of medium size, subcircular, height slightly less than length, moderately convex. Posterior area sharply depressed; anterior area narrow, moderately depressed, lateral margin slightly sinuate. Concentric lamellae of moderate height and spacing. Interior unknown.

Length 36.8 mm, height (incomplete) 32.5 (estimated restored height 35.5 mm, convexity about 11 mm (largest specimen).

Six incomplete or immature valves from the Culebra formation and two in poor condition from the La Boca formation are similar to *Phacoides domingensis* (Dall, 1890–1903, pt. 6, p. 1363, not pl. 50, fig. 11, 1903), which was based on an articulated specimen from strata of unknown age on an island in Lago Enriquillo, in the Dominican Republic. Whether it can be distinguished from *P. pectinata* by any feature other than its smaller size is doubtful.

My colleague Druid Wilson has reminded me that the type of *P. domingensis* (an articulated specimen, USNM 113678, length and height about 35 mm) has not been illustrated. The specimen illustrated by Dall, as he stated, is a small left valve from the Tampa limestone of Florida (USNM 157640, length 22.6 mm, height 21.5 mm).

Though the genus is unknown in the modern eastern Pacific fauna, a species occurs in the Miocene of Ecuador: *P. pacifica* (Olsson, 1964, p. 46, pl. 6, fig. 4).

Occurrence: Culebra formation (early Miocene), localities 107, 108c, 110. La Boca formation (early Miocene), Gaillard Cut area, localities 101, 116a.

Genus Lucina Bruguiere

Bruguière, Encyclopédie méthodique, Histoire naturelle des vers, v. 1, pls. 284–286, 1789 (genus without named species).

Type (logotype, Schumacher, Essai d'un nouveau système des habitations des vers testacés, p. 165, 1817): *Lucina pennsylvanica* (*Venus pensylvanica* Linné), living, North Carolina and Gulf of Mexico to northern Brasil.

Subgenus Lepilucina Olsson

Olsson, Neogene, mollusks from northwestern Ecuador, p. 47, Paleontological Research Inst., 1964.

Type (orthotype): *Lucina* (*Lepilucina*) *gratis* Olsson, Miocene, Ecuador.

Lepilucina is distinguished by its strong, upturned, widely spaced concentric lamellae.

Lucina (Lepilucina) aff. L. gratis Olsson

Plate 92, figure 3

Moderately small, vertically ovate, strongly inequilateral, moderately convex. Posterior area slightly depressed; anterior area strongly depressed, short and narrow. Lunule not exposed. Concentric lamellae strong, widely spaced, but edge not upturned (except near ventral margin) as much of outer shell material is missing. Interior inaccessible.

Length 31.8 mm, height 28.8 mm, convexity about 5 mm (figured left valve).

The Culebra formation yielded a left valve, (for the most part an internal mold) and an internal mold of an articulated specimen of this early *Lepilucina*, the only known species of the subgenus other than the type species, the next species described. It is slightly larger than the type species and decidedly less inequilateral.

Occurrence: Culebra formation (early Miocene), locality 106, 111.

Lucina (Lepilucina) gratis Olsson

Plate 111, figures 3, 4, 7, 9, 11

Lucina (*Lepilucina*) *gratis* Olsson, Neogene mollusks from northwestern Ecuador, p. 47, pl. 7, figs. 1–1c, Paleontological Research Inst., 1964 (Miocene, Ecuador).

Small, vertically ovate, inequilateral, moderately convex. Posterior and anterior areas well defined; anterior area short and narrow. Lunule under tip of umbo, separated from depressed anterior area by swelling, which widens outward to lateral margin. Sculpture consisting of strong, widely spaced, concentric lamellae, edge upturned, but on some specimens broken off except in posterior area. Faint traces of hidden fine radial sculpture. Right anterior cardinal tooth suppressed. Anterior lateral tooth peglike, located opposite swelling bordering depressed anterior area. Inner margin of valve smooth, but an inner layer is finely crenulated.

Length 25.2 mm, height 24 mm, convexity (both valves) 11.5 mm (figured articulated specimen). Length 27.4 mm, height 26.3 mm, convexity (both valves) about 12 mm (largest complete specimen).

Type: USNM 644095; three figured paratypes USNM 644096, 644097, 645396.

Type locality: Cueva de Angostura, Esmeraldas Province, Ecuador. Angostura formation.

This unusual lucinid, *Lirophora*-like in sculpture, is represented by 10 specimens (four articulated) and two fragments from the middle part of the Gatun formation and by a pair of matching right and left valves from the upper part in the eastern area.

Lucina gratis, like *Calloarca cachla* (P 306–E, p. 497), has so far been found only in middle Miocene deposits in Ecuador and the Canal Zone.

Occurrence: Middle and upper parts of Gatun formation (middle Miocene). Middle part, eastern area, locality 139g; western area, locality 161. Upper part, eastern area, locality 176a. Angostura formation (middle Miocene), Ecuador.

Genus Plastomiltha Stewart

Stewart, Acad. Nat. Sci. Philadelphia Special Pub. 3, 191, 1930.

Type (orthotype): *Cyclas claibornensis* Conrad, Eocene, Alabama.

Plastomiltha? odontota Woodring, n. sp.

Plate 84, figures 4–6

Of medium size, subcircular, height slightly less than length, subequilateral, valves of moderate and subequal convexity. Posterior area distinctly depressed, anterior area slightly depressed. Lunule elongate, narrow. Concentric lamellae low, erect, closely spaced. Microscopic radial sculpture between lamellae. Cardinal part of right valve damaged, anterior tooth apparently effaced by lunule; an anterior and posterior lateral tooth, anterior one located beyond anterior end of lunule. Hinge of left valve unknown. Anterior adductor scar long.

Length 30.3 mm, height 27.1 mm, convexity (both valves) 13.5 mm (type).

Type (articulated specimen): USNM 647335; paratype (right valve) USNM 647336.

Type and paratype locality: 23b (USGS 24553, upper course of Río Palenque, 3.4 km in direct line west of Nuevo San Juan and 1.3 km northwest of settlement of Palenque, Colón Province, Panamá), Gatuncillo formation.

Plastomiltha? *odontota* is represented, in a collection from the Gatuncillo formation, by two right valves and an articulated specimen. In outline, posterior and anterior areas, and sculpture including microscopic radial sculpture, it is similar to the type species of *Plastomiltha* (Harris, 1919, p. 121, pl. 39, figs. 8, 9; Eocene, Alabama). It differs from the type species, however, by the presence of a well-developed anterior and posterior lateral tooth, at least on the right valve.

Occurrence: Gatuncillo formation (late Eocene), locality 23b.

Genus Bellucina Dall

Dall, U. S. Natl. Mus. Proc., v. 23, p. 806, 1901.

Type (orthotype): *Parvilucina eucosmia* Dall, 1901 (substitute name for *Lucina pisum* Reeve, 1850, not *Lucina pisum* Sowerby, 1836) = *Lucina semperiana* Issel, 1869, living, western Pacific and Indian Oceans.

Bellucina actinus (Dall)

Plate 112, figures 2–4

Phacoides (*Bellucina*) *actinus* Dall, Wagner Free Inst. Sci., Trans., v. 3, pt. 6, p. 1385, pl. 52, fig. 3, 1903 (Miocene, Jamaica). Woodring, Carnegie Inst. Washington Pub. 366, p. 126, pl. 17, figs. 5–8, 1925 (Miocene, Jamaica).

Phacoides actinus Dall, Maury, Bull. Am. Paleontology, v. 5, no. 29, p. 206 (assigned to section *Bellucina*). 1917 (Miocene, Dominican Republic). Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 224 (assigned to section *Bellucina*), pl. 32, fig. 24, 1922 (Miocene, Panamá).

?*Phacoides actinus uscarensis* Palmer, Bull. Am. Paleontology, v. 10, no. 40, p. 12 (assigned to section *Bellucina*), pl. 2, figs. 1, 3, 1923 (Miocene, Costa Rica).

?*Lucina* (*Codakia*) *dariena* Toula, K. k. Geol. Reichsanstalt Jahrb., v. 61, p. 494, pl. 31, figs. 3a, 3b (*gatunensis* in explanation of plate), 1911 (Miocene, Canal Zone).

Small, generally subcircular, height little less than length; exceptionally ovate and somewhat inequilateral, anterior end extended. Moderately convex. Anterior dorsal margin concave, posterior dorsal margin slightly convex to practically straight. Posterior and anterior areas slightly depressed or not depressed, but recognizable by absence of radial sculpture. Lunule moderately narrow, escutcheon very narrow. Radial sculpture, below umbonal area, of low arched ribs, 20 to 28 at ventral and lateral margins (generally less than 25), almost invariably wider than interribs, exceptionally of about same width. Ribs overridden by low, very narrow concentric lamellae. Minute shells (height 0.5 to 1 mm) smooth or almost smooth; both sets of sculpture greatly suppressed even on some mature valves. Hinge strong for size of shell: two cardinal teeth and anterior and posterior lateral teeth on both valves. Interior margin strongly crenulated; crenulations weak even on smooth or almost smooth minute valves.

Length 4.35 mm, height 4.1 mm, convexity 1.25 mm (larger figured valve).

Type: Lectotype, herewith designated, right valve illustrated in exterior view by Dall, USNM 135719.

Type locality: Bowden, Jamaica, "shell bed" in Bowden formation.

This small species is by far the most widespread and locally most abundant lucinid in the Gatun formation, especially in the middle part. The number of specimens in the three parts of the formation is as follows:

Distribution of Bellucina actinus

Gatun formation	*Number of specimens*
Upper part, eastern area	19
Middle part	[1]1,000
Lower part	150

[1] Estimate.

The estimate for the middle part includes an estimate of 600 from the unusual locality for small shells: locality 147b on the Panama Railroad.

Minute valves (height 0.5 to 1 mm) are abundant, especially in the lower part and in strata near the base of the middle part. In fact, seven of the nine lots from the lower part consist only of minute valves. The collections from localities 146, 147b, 147g, and 169, all in the middle part, are the only ones that show a graded growth series from minute to mature. Mature shells are not common in any collection. Collections of at least fair size include some articulated specimens. The hinge of valves from the upper part at locality 163—the only locality in the upper part that yielded valves of moderate size showing the hinge—is weaker than that of valves from the other parts.

On the lectotype, the concentric lamellae are wider on the ribs than in the interribs, but that feature is not consistent among the numerous topotypes. Though many valves from the Gatun have more ribs than Jamaican valves, the maximum number for Jamaican specimens (22) is within the range of the number for Canal Zone specimens. *Phacoides actinus uscarensis* is a large form (height 6 mm), but the rib count (22) is not significant. *Lucina dariena* seems to be an immature *Bellucina actinus* (length 2.9 m, height 2.5 mm). If so, however, the hinge is not properly drawn.

B. actinus is a well-defined species. It lacks the wide ribs of the species living in the western Atlantic and eastern Pacific Oceans—*B. amiantus* (Dall) and *B. cancellaris* (Philippi), respectively—and of the Miocene and Pliocene allies of those species in southeastern United States.

Occurrence: Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, localities 136a, 137, 138, 138a, 138b, 138c, 138d, 138f, 138g, 138h. Middle part, eastern area, localities 139b, 139c, 139e, 139g, 146, 147b, 147f, 147g, 147h, 153a, 155, 155a, 155b, 155c, 157, 159d; western area, localities 161c, 169. Upper part, eastern area, localities 163, 173, 173a, 177, 177b, 178. Subsurface early Miocene part of Uscari shale, Limón Province, Costa Rica (identification doubtful). Bowden formation (middle Miocene), Jamaica. Cerado formation (middle Miocene), Dominican Republic (Maury's record). Limónes formation (late Miocene), Bocas del Toro area, Panamá.

Genus Luciniscа Dall

Dall, U.S. Natl. Mus. Proc., v. 23, p. 805, 1901.

Type (orthotype): *Lucina nassula* Conrad, living, North Carolina to Gulf of Mexico and West Indies.

Lucinisca protista Woodring, n. sp.

Plate 90, figure 2

Small, height little less than length to little more than length. Posterior area depressed, anterior area not depressed. Concentric lamellae evenly and fairly widely spaced, except in umbonal area, where they are closely spaced. Radial riblets low, narrow, closely spaced, slightly frilling edge of lamellae; absent or indistinct on posterior and anterior areas. Interior inaccessible.

Length 7.7 mm, height 8.3 mm, convexity about 3 mm (type). Length 10.5 mm, height 9 mm, convexity about 3 mm (larger valve).

Type (left valve): USNM 647626.

Type locality: 42 (USGS 17692, northeast coast of Trinidad Island, sandy siltstone, basal 3 m of exposed section, Canal Zone), marine rocks of late Eocene age.

Two left valves of *Lucinisca protista*, from the marine rocks of late Eocene age, are of interest as the earliest *Lucinisca* now known in the Tertiary Caribbean province. The sculpture is similar to that of the following species, but the radial riblets of the valves from the upper Eocene marine rocks are stronger.

Occurrence: Marine rocks of late Eocene age, locality 42.

Lucinisca cf. L. calhounensis (Dall)

Small, height little less than length. Posterior area slightly depressed, anterior area not well preserved Concentric lamellae evenly spaced except near ventral margin, where they are more closely spaced. Narrow, low, closely spaced radial riblets weak on dorsal half of valve, somewhat stronger and frilling edge of lamellae on ventral half. Interior inaccessible.

Length 8.5 mm, height 7.5 mm (largest specimen).

Three small valves of *Lucinisca* from the La Boca formation are in poor condition. The largest partly disintegrated during handling. The radial riblets are lower than those of *L. calhounensis* (Dall, 1890–1903, p. 1371, pl. 52, fig. 16, 1903), from the early Miocene Chipola formation of Florida, and do not override the lamellae.

Occurrence: La Boca formation (early Miocene), Gaillard Cut area, localities 99b, 100a.

Lucinisca bocasensis (Olsson)

Plate 111, figures 8, 12

Phacoides bocasensis Olsson, Bull, Am. Paleontology, v. 9, no. 39, p. 223 (assigned to subgenus *Lucinisca*), pl. 32, fig. 6, 1922 (Miocene, Bocas del Toro area, Panamá).

Of medium size, height little less than length. Posterior and anterior areas distinctly depressed. Lunule narrow. Immature valves and umbo of mature valves sculptured with concentric lamellae of variable strength and spacing; a bizarre immature valve has very strong and very widely spaced lamella, except at tip of umbo, where they are very strong and very closely spaced. Lamellae progressively more closely spaced adventrally on mature valves. Radial riblets narrow and closely spaced, some intercalated riblets still narrower. On ventral part of shell lamellae forming elongate scales on ribs. Inner part of posterior area sculptured with thin lamellae, outer part with scaly riblets. Anterior area sculptured with scaly riblets. Anterior right cardinal tooth absent. Lateral teeth on both valves. Interior valve margin finely crenulated.

Length 21.4 mm, height 20 mm, convexity 5.3 mm (figured left valve).

Type: Paleontological Research Inst. 21323.

Type locality: Bocas del Toro [Isla de Colón], Bocas del Toro area, Panamá, Limónes formation.

Though six valves of this *Lucinisca* were found in the Gatun formation, only two are mature: the illustrated left valve from the middle part and a right valve from the upper part, the extreme posterior part of which is missing, except adjoining the ventral margin. The bizarre immature valve (height 10.8 mm, locality 171), mentioned in the description, is much like the lectotype of *L. nuttallii centrifuga* (Dall, 1901, p. 828, pl. 39, fig. 13; living, Gulf of California), except that the lamellae of the fossil are heavier and not spinose. It is recommended that the name *L. nuttallii centrifuga* be suppressed. The sculpture of the 19 immature specimens in the type lot is variable, and other lots from both sides of Baja California lack the sculpture of the lectotype—Dall's illustrated specimen.

The mature Canal Zone valves are twice as large as the type of *L. bocasensis*, the only available specimen. Perhaps *L. bocasensis* is a synonym of *L. hispaniolana* (Maury, 1917, p. 204, pl. 35, fig. 4; Miocene, Dominican Republic). However that may be, the Canal Zone fossils are more similar to *L. fausta* (Pilsbry and Olsson, 1941, p. 58, pl. 17, figs. 3, 6; Pliocene, Ecuador), which may be a relatively small form of the living eastern Pacific *L. fenestrata* (Hinds), than to either of the living western Atlantic species: *L. nassula* (Conrad) and *L. muricata* (Spengler).

Occurrence: Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, locality 138c. Middle part, eastern area, locality 155. Upper part, eastern area, localities 171, 173a, 177c. Limónes formation, Bocas del Toro area, Panamá.

Genus Parvilucina Dall

Dall, U. S. Natl. Mus. Proc., v. 23, p. 806, 1901.

Type (orthotype): *Lucina tenuisculpta* Carpenter, living, Bering Sea to San Diego, California.

It seems strange that *Parvilucina* has not been found in the Gatun formation.

Parvilucina cf. P. yaquensis (Gabb)

Though 18 valves from the La Boca formation are in poor condition, they show enough to be identifiable as *Parvilucina*. The posterior and anterior areas are not depressed. The fine concentric sculpture is weak, and some valves show traces of radial sculpture. The interior is not clearly exposed on any. So far as they go, these fossils are similar to *P. yaquensis* (Maury, 1917, p. 206, pl. 35, fig. 8), which is abundant in the Cercado formation of the Dominican Republic. The largest of the fossils from the La Boca has a length of 4.8 mm and a height of 4.5 mm.

Occurrence: La Boca formation (early Miocene), Gaillard Cut area, localities 99c, 100a, 101d, 102, 102a.

Genus Codakia Scopoli

Scopoli, Introductio ad historiam naturalem * * *, p. 398, 1777.

Type (monotype): *Chama codok* Adanson [Chama 3, Le Codok, pre-Linnean] – *Venus orbicularis* Linné (see Fischer-Piette, 1942, p. 306, pl. 14, fig. 3), living, Florida and southern Gulf of Mexico to Cabo Frio, Brasil.

Subgenus Codakia s.s.

Codakia (Codakia) species

Large, subcircular, height little less than length, moderately convex. Posterior area slightly depressed. Sculpture consisting of very narrow concentric lamellae, about a third as wide as space between them, and very fine crowded radial threads. Interior unknown.

Length (practically complete) 67 mm, height 56.5 mm.

Two right valves, both in poor condition, from the La Boca formation, represent *Codakia*. Though most of the outermost shell is not preserved, enough of the sculpture is preserved to show that the concentric lamellae are very narrow, narrower and more widely spaced than those of the living *C. orbicularis* and it's eastern Pacific counterpart *C. distinguenda* (Tryon). A comparable specimen from locality 101i that shows no radial sculpture is doubtfully identified as *Codakia*.

Occurrence: La Boca formation (early Miocene), Gaillard Cut area, locality 101i (identification doubtful), 102a; Summit area, locality 127.

Genus Miltha Henry and Arthur Adams

Henry and Arthur Adams, The genera of Recent Mollusca, v. 2, p. 468, 1857.

Type (monotype): [*Lucina*] *Childreni* [*Childrenae*] Gray, living, Pará to Bahia, Brasil.

Miltha species

Plate 91, figure 25

Small, vertically ovate, height slightly greater than length. Left valve apparently slightly more convex than right. Umbo low. Lunule large for size of shell, wider on right valve than on left, deeply impressed. Posterior area sharply depressed, not set off by groove; anterior area narrow, depressed. Concentric lamellae of variable strength, strongest near lateral margins of valve, especially strong on posterior area, greatly subdued on anterior area. Faint radial sculpture not apparent. Interior inaccessible.

Length 23 mm, height 24 mm, convexity about 3 mm (figured right valve).

Though this *Miltha* is of interest as the first Oligocene species to be recorded—and perhaps the earliest species of the genus—it is not named, as the interior is unknown. It is represented by the illustrated right valve and a somewhat larger articulated specimen, which was in such poor condition that it disintegrated. It still shows, however, the lunule on both valves. Both were found in the upper part of the Bohio formation on Barro Colorado Island.

The umbo is lower than that of *M. chipolana* of comparable size, and the anterior dorsal margin therefore is not as concave as that of *M. chipolana*, and the posterior area is not set off by a groove. Whether these features would be consistent in a larger sample remains to be seen.

Occurrence: Bohio formation (late Oligocene), localities 42d, 42f.

Miltha chipolana (Dall)?

Plate 111, figures 1, 2, 14

Small, vertically ovate, height slightly greater than length. Left valve slightly convex. Right valve represented only by two very small valves. Umbo relatively high. Lunule small, deeply impressed. Posterior area depressed, set off by narrow groove; anterior area narrow, depressed. Concentric lamellae of variable strength and spacing, strongest near lateral margin of valve, especially strong on posterior area, weak on anterior area. Faint radial sculpture between lamellae on central ventral half of valve. Radial sculpture anastomosing and extending across lamellae, which are worn, near ventral margin of figured valve. Narrow shallow groove extending across posterior muscle scar, alined with pallial line. Wider shallow groove starting from inner edge of anterior muscle scar below midpoint of its height and extending obliquely upward. Two cardinal teeth in each valve.

Length 22.9 mm, height 23.3 mm, convexity 3.3 mm (figured left valve). Length 23 mm, height 24 mm, convexity 3.6 mm (left valve).

The middle part of the Gatun formation yielded two small left valves of *Miltha* and two very small right valves (height 13.6 and 9.6 mm). All were collected at the Gatun Third Locks excavation. They may not show any feature, other than their small size, to distinguish them from *M. smithwoodwardi* (Maury, 1917, p. 204, pl. 35, fig. 6). The anastomosing radial sculpture on the worn ventral part of the illustrated valve may, however, indicate a significant difference in shell structure. Such sculpture is not shown on the corresponding unworn part of the other left valve, nor on the somewhat worn corresponding part of *M. smithwoodwardi*, nor on *M. chipolana*. *M. smithwoodwardi* was based on a left valve from the Cercado formation of the Dominican Republic (height 50 mm). A smaller right valve (height 41.8 mm), also from the Cercado, in USNM collections is the only other known specimen. These fossils apparently show no feature, other than their small size, to distinguish them from *M. chipolana*, which reaches a height of some 80 mm. To be sure, none of the six valves under consideration shows a radial swelling on the posterior area adjoining the groove that sets off the area, but the swelling is present or absent on valves of *M. chipolana*.

The type of *M. chipolana* (Dall, 1890–1903, p. 1375, pl. 51, fig. 11, 1903) is an incomplete right valve (USNM 114712). As implied by the name, the type locality is in the Chipola formation. Gardner (1926–47, p. 111, pl. 19, figs. 5, 6, 1926) illustrated a complete right valve from the Oak Grove sand member of the Shoal River formation. Vokes (1969, especially p. 118–120, pl. 1, fig. 3, pl. 2, figs. 4a, 4b, pl. 3, pl. 5, text fig. 1), who studied an exceptionally large sample from the Chipola, found the species to be variable. He considered *M. smithwoodwardi* to be a synonym of *M. chipolana*. What is really needed are larger samples from the Dominican Republic and the Canal Zone.

An early Miocene Brasilian *Miltha* has been identified as *M. childreni* [*childrenae*] (Ferreira, 1966).

Occurrence: Middle part of Gatun formation (middle Miocene), eastern area, localities 155, 155a, 155c.

Genus Pseudomiltha Fischer

Fischer, Manuel de conchyliologie, p. 1144, 1887.

Type (orthotype): *L[ucina] gigantea* Deshayes, Eocene, Europe, northern Africa, Pakistan.

Small internal molds that show radial markings, from the Gatuncillo formation at locality 12, are listed as *Pseudomiltha*? sp.

Pseudomiltha megameris (Dall)

Plate 88, figure 1

Lucina megameris Dall, Nautilus, v. 15, p. 41, 1901 (Eocene, Jamaica).

Phacoides (*Pseudomiltha*?) *megameris* (Dall), Dall, U. S. Nat. Mus. Proc. v. 23, p. 829, pl. 42, fig. 1 (about ⅓ natural size), 1901 (Eocene, Jamaica).

Phacoides (*Pseudomiltha*) megameris (Dall), Cox, Malacological Soc. London Proc., v. 24, p. 136, pl. 8, fig. 1, 1941 (Eocene, Jamaica).

Pseudomiltha megameris (Dall), Richards, *in* Richards and Palmer, Florida Geol. Survey Geol. Bull. 35, p. 48, pl. 10, fig. 6, 1953 (Eocene, Florida). Jung, Naturforsch. Gesell, Basel Verh., v. 84, no. 1, p. 493, 1974 (Eocene, Curaçao).

Pseudomiltha? cf. *P. haitensis* Woodring and Mansfield, Woodring and Daviess, U. S. Geol. Survey Bull. 935-G, p. 373 (list), 1944 (Eocene, Cuba).

Very large, inequilateral, obliquely ovate, valves of moderately strong and subequal convexity, or right valve slightly more convex than left. Height less than length, umbo low. Posterior area depressed; anterior area short, narrow, depressed. Traces of irregularly spaced, low concentric lamellae. Anterior adductor scar very long, extending beyond midpoint of ventral margin.

Length 19 cm, height 16.5 cm, convexity (both valves) 6 cm (figured specimen, largest specimen). Length 15.7 cm, height 14 cm, convexity (both valves) 5 cm.

Type: USNM 147592.

Type locality: Claremont, St. Ann Parish, Jamaica, Versey's Claremont limestone of White limestone group.

Three specimens of *Pseudomiltha megameris*, two large and one of medium size, were found in limestone of the Gatuncillo formation in Madden basin. Though they are chiefly internal molds of articulated valves, some more or less corroded shell material remains, especially on the anterior and ventral parts of the larger illustrated specimen, covering the very long anterior muscle scar. That specimen does not show the anterior area, and part of the posterior area is disfigured by rock matrix. The areas and scar are shown on the smaller large specimen.

This species is the largest described lucinid. In Jamaica and Cuba the outline is variable. The most elongate and most inequilateral of seven Jamaican specimens in USNM collections has a length of 27.5 cm and a height of 22 cm, as compared with 28 and 24.5 cm, respectively, for the least elongate and least inequilateral. The specimen from Florida illustrated by Richards is exceptional. It is practically equilateral and the height is greater than the length.

Wherever the species has been found, it occurs in limestone.

Occurrence: Gatuncillo formation (late Eocene), localities 9, 11. Avon Park limestone (middle Eocene), Florida. Charco Redondo limestone member of Cobre formation (middle Eocene), Oriente Province, Cuba (USGS 17954). Inglis limestone (of former usage) (late Eocene), Florida. Limestone of late Eocene age, Las Villas Province, Cuba (USGS 20464). Versey's Claremont limestone of White limestone group (late Eocene), Jamaica. Ceru di Cuebra formation (middle or late Eocene), Curaçao.

Genus Lucinoma Dall

Dall, U. S. Nat. Mus. Proc., v. 23, p. 806, 1901.

Type (orthotype): *Lucina filosa* Simpson, living, western North Atlantic Ocean.

Lucinoma is basically a northern genus. At present it does not range farther south than Cuba and Jamaica in the western Atlantic Ocean and not south of the Gulf of California in the eastern Pacific Ocean. The species of the present account are the first Tertiary species to be recorded from the present Caribbean region. Though they have been found in the Culebra and Gatun formations and the Chagres sandstone, the representation is meager except in the Chagres.

A poorly preserved left valve of medium size from the Culebra is listed as *Lucinoma* sp. a.

Lucinoma species b

Plate 111, figure 10

Moderately small, suborbicular, height slightly less than length, strongly convex. Lunule not preserved; elongate and narrow according to outline of inner edge on right valve. Posterior and anterior areas poorly defined. Sculpture of closely spaced, low, erect concentric lamellae. Interior inaccessible.

Length (almost complete) 30 mm, height (almost complete) 26 mm, convexity (both valves) 15.9 mm (figured specimen).

Lucinoma sp. b is represented by an articulated specimen from the middle part of the Gatun formation. It is more convex than *L. playaensis* (Olsson, 1964, p. 49, pl. 6, fig. 7; Oligocene, Ecuador), and its lamellae are lower and more closely spaced.

Occurrence: Middle part of Gatun formation (middle Miocene), eastern area, locality 147j.

Lucinoma tapeina Woodring, n. sp.

Plate 121, figure 9

Small, suborbicular, height slightly less than length, slightly convex. Lunule not preserved. Posterior and anterior areas not defined. Sculpture of closely spaced, low concentric lamellae. Interior inaccesible.

Length 25.8 mm, height 22.5 mm, convexity (both valves) 10 mm (type). Length (incomplete) 20 mm (estimated restored length 29 mm), height 26 mm, convexity (both valves) 13 mm (largest specimen).

Type (articulated specimen): USNM 647747.

Type locality: 204 (USGS 8441, 1.5 miles (2.4 km) east (northeast) of mouth of Río Charges, 1,000 ft (300 m) from ocean, Canal Zone), Chagres sandstone.

Nine specimens from the type locality and two from other localities in the Chagres sandstone, all of which are somewhat corroded, are assigned to this small species. It is much smaller than *Lucinoma chiripanica* (Olsson, 1942a, p. 36, pl. 4, figs. 1, 4; 1964, p. 49, pl. 6, fig. 12), which occurs in the Charco Azul formation of the Panamá-Costa Rica border and in the Esmeraldas formation of Ecuador, and has sculpture of only one order of magnitude.

Occurrence: Chagres sandstone (late Miocene or early Pliocene), localities 197, 200, 204.

Genus?

"Lucinoma" species

Plate 111, figures 5, 6

Small, weakly convex. Anterior dorsal margin deeply concave; posterior dorsal margin slightly convex. Remainder of outline unknown. Lunule elongate, relatively very wide. Anterior dorsal part flatter than posterior dorsal part, but posterior and anterior areas absent, at least on dorsal part. Sculpture of narrow, low, widely spaced concentric lamellae. Two cardinal teeth on left valve, posterior one thin. Right valve unknown.

Length (incomplete) 8.8 mm, height (incomplete) 11.2 mm, convexity 2.3 mm (figured specimen).

The lower part of the Gatun formation yielded the dorsal part of the left valve of a lucinid of undetermined affinities. It is somewhat *Lucinoma*-like, but the deeply concave anterior dorsal margin, relatively very wide lunule, and very widely spaced concentric lamellae show that it is not *Lucinoma*.

Occurrence: Lower part of Gatun formation (middle Miocene), locality 138d.

Genus Myrtaea Turton

Turton, Conchylia Insularum Britannicarum, p. 133, 1822.

Type (monotype): *Venus spinifera* Montagu, living eastern North Atlantic Ocean and Mediterranean Sea.

Subgenus Myrtaea s.s.

A poorly preserved valve from the La Boca formation is listed as *Myrtaea*? (*Myrtaea*?) sp.

Myrtaea (Myrtaea) cf. M. curta (Conrad)

Minute, height barely less than length, slightly elliptical horizontally. Anterior dorsal margin concave, posterior dorsal margin straight. Suggestion of narrow, slightly depressed posterior area; anterior area indistinguishable. Sculpture of low, moderately closely spaced concentric lamellae, not extended on dorsal margin. Right hinge consisting of median cardinal tooth and short anterior and posterior lateral teeth.

Length 2.4 mm, height 2.1 mm (smaller of two right valves).

Two minute right valves were recovered from the Gatuncillo formation at locality 23b. Though without much doubt they are immature, they are of interest as the earliest *Myrtaea* so far recorded from the Tertiary Caribbean province. The absence of extensions of the concentric lamellae on the dorsal margins suggests immaturity. The smaller of the two is well preserved; the other, which is incomplete, has a length of about 3 mm.

M. curta (Conrad), (Harris, *in* Harris and Palmer, 1946–47, p. 89, pl. 19, figs. 19–23, 1946), a late Eocene species from Mississippi, reaches a length of 7 mm. Its concentric lamellae are more closely spaced than those of the fossils from the Gatuncillo.

Occurrence: Gatuncillo formation (late Eocene), locality 23b.

Myrtaea (Myrtaea) enischna Woodring, n. sp.

Plate 91, figures 5, 6

Small to moderately small, thin-shelled, subcircular, height generally little less than length, moderately convex. Anterior dorsal margin slightly convex. Posterior area flattened, but not depressed; anterior area indistinguishable. Lunule elongate, very narrow. Concentric lamellae low and closely spaced; higher and more widely spaced near ventral margin of largest valves. Interior inaccessible.

Length 10.2 mm, height 9.9 mm, convexity about 4 mm (type).

Type (left valve): USNM 647337; paratype (left valve) USNM 647338.

Type and paratype locality: 54h (USGS 18841, Barro Colorado Island, western part of island, mouth of first stream north of Zetek House, Canal Zone), Caimito formation.

Twenty-five specimens of this small *Myrtaea* were found in the moderately deep water facies of the Caimito formation on Barro Colorado Island. On nearly all of them the shell material is corroded and on a few it is entirely dissolved. The type lot consists of 13 specimens, ranging in length from 5.8 to 10.2 mm. Two larger than any in the type lot were collected at locality 54j. The larger of the two has a length of 16 mm. The sculpture is shown to best advantage on the incomplete paratype.

M. enischna is larger than *M. vicksburgensis* (Casey, 1903, p. 263; Oligocene, Mississippi) and lacks the slightly depressed posterior area and crowded concentric lamellae of that species. Both posterior and anterior areas of *M. taylorensis* (Mansfield, 1940, p. 191, pl. 25, figs. 20, 21; Oligocene, Mississippi) are depressed.

Occurrence: Caimito formation (late Oligocene), localities 54h, 54j, 54k.

Genus Megaxinus Brugnone

Brugnone, Soc. Malacologia Italiana Bull., v. 6, p. 146, 1880.
Type (orthotype): *Lucina rostrata* Pecchioli = *Lucina elliptica* Borson, Miocene and Pliocene, Italy.

Megaxinus? sp.

Lucina spec. aff. *Lucina* (*Megaxinus*) *Bellardiana* May[er], Toula, K. k. Geol. Reichsanstalt Jahrb., v. 58, p. 719, pl. 25, fig. 19, 1909 (Miocene, Canal Zone).

Toula's illustration of a right valve of a lucinid of medium size from the Gatun formation suggests the western European genus *Megaxinus*, as he thought. It has not been recognized in the collections under study.

Occurrence: Middle part of Gatun formation (middle Miocene), Toula's record.

Genus Pegophysema Stewart

Stewart, Acad. Nat. Sci. Philadelphia Spec. Pub. 3, p. 185, 1930.
Type (orthotype): *Lucina schrammi* crosse, living, Bermuda, Florida, and Gulf of Mexico to West Indies.

The identification of *Anodontia alba* Link, the monotype of *Anodontia* (Link, 1806–07, p. 156, 1807) is uncertain. Until the uncertainty is resolved, Stewart's name, the type species of which has an extant type, is preferred. This species, the larger of the two species of the genus living in the West Indies, was identified by Dall (1890–1903, p. 1355, 1903) as *Lucina philippiana* Reeve.

Pegophysema cf. P. mauryae (Pilsbry and Johnson)

Plate 92, figures 6, 7; plate 95, figure 10

Of medium size, equilateral, height less than length, strongly convex. Anterior area generally flattened, pinched together on articulated valves; exceptionally slightly depressed. Posterior area indistinguishable or barely distinguishable. Lunule narrow or very narrow on left valve, absent on right valve on two specimens that show lunule on left valve. Growth lines weak. Interior inaccessible.

Length 43 mm, height 39.8 mm, convexity (both valves) 22 mm (figured specimen from Caimito formation). Length 42.5 mm, height 38.4 mm, convexity about 10 mm (figured specimen from La Boca formation).

Ten specimens from the Caimito formation and five from the La Boca formation are identified as *Pegophysema* cf. *P. mauryae*. All are articulated. Those from the Caimito retain more or less shell material, but those from the La Boca retain little or none.

The posterior area of the type of *P. mauryae* (Pilsbry and Johnson, 1917, p. 198; Pilsbry, 1922, p. 417, pl. 46, fig. 3), from an unknown, presumably Miocene, locality in the Dominican Republic, is distinctly depressed, whereas the area on the Canal Zone fossils is indistinguishable or barely distinguishable. To be sure, the range of variation for *P. mauryae* is unknown. The Canal Zone species is smaller than the living Caribbean species variously known as *Anodontia alba* Link and *Lucina chrysostoma* (Meuschen) Phillipi (Dall's designation, 1890–1903, p. 1354, 1903), and the posterior and anterior areas of the fossils are less distinct.

Occurrence: Caimito formation (late Oligocene), locality 56. La Boca formation (early Miocene), Gaillard Cut area, locality 101e; Summit area, localities 127, 128.

Pegophysema janus (Dall)

Plate 111, figures 13, 15–17

Lucina janus Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 6, p. 1353 pl. 51, fig. 9, 1903 (Miocene, Florida). Gardner, U.S. Geol. Survey Prof. Paper 142, p. 105, pl. 18, fig. 5, 1926 (Miocene, Florida).

Lucina (*Loripes*) sp. (n. sp.?) aff. *Loripes edentula* Linné, Toula, K. k. Geol. Reichsanstalt Jahrb., v. 58, p. 720, pl. 27, fig. 3, 1909 (Miocene, Canal Zone).

Of medium size, subequilateral, strongly convex. Posterior area slightly to distinctly depressed. Anterior area generally more or less flattened but not well defined; exceptionally depressed and outer margin sinuate at ventral end. Lunule elongate, narrow to very narrow, only on left valve on three articulated specimens that show it, and only on right valve on one. Growth lines well defined, some exaggerated. Faint, generally microscopic, radial lineation. Hinge edentulous. Remainder of interior inaccessible.

Length 39.8 mm, height 34.3 mm, convexity (both valves) 23 mm (smaller figured specimen). Length 41.4 mm, height 36.2 mm, convexity (both valves) 27 mm (larger figured specimen).

Type: USNM 114718.

Type locality: USGS 2213, 1 mile below Baileys Ferry, Chipola River, Calhoun County, Fla., Chipola formation.

Thirty-five specimens of this species are in collections from the Gatun formation, all except one from the middle part. All except six are articulated. It seems remarkable that this edentulous genus is represented by Oligocene and Miocene articulated specimens. It generally is represented by internal molds of articulated valves throughout the Caribbean region, especially in the limestones of Cuba, Puerto Rico, and Anguilla.

Only one specimen from the Gatun has a depressed, sinuate anterior area (pl. 111, fig. 16). That kind of an anterior area is shown by all except two of some 40 in the type lot of *Pegophysema santarosana* (Dall, 1890–1903, p. 1354, pl. 51, fig. 6, 1903; Miocene, Florida). Perhaps at the species level the genus is overnamed in the Alum Bluff group of Florida.

An immature articulated specimen from the Emperador limestone member of the La Boca formation in the Gaillard Cut area is doubtfully identified as *P. janus*.

Occurrence: Emperador limestone member of La Boca formation (early Miocene), Gaillard Cut area, locality 129 (identification doubtful). Middle and upper parts of Gatun formation (middle Miocene). Middle part, eastern area, localities 139g, 146, 150a, 153, 155, 155b, 155c, 156, 157, 159b; western area, locality 166. Upper part, eastern area, locality 173. Chipola formation (early Miocene), Florida.

Genus Hadralucina Woodring, n. gen.

Type: *Anodontia*(?) *augustana* Gardner (1951, p. 9, figs. 1a–1e), Eocene, Alabama, South Carolina.

Thin-shelled or shell of moderate thickness, large to very large (length 77 to 145 mm), elongate-subelliptical, generally moderately inequilateral, very strongly convex. Anterior dorsal margin generally almost straight; posterior dorsal margin slightly convex or straight. Umbo high, very wide, full. Sculpture limited to irregular, subdued growth lines. Hinge edentulous. Adductor scars unknown. Faint radial markings on internal molds.

The large size, elongate-subelliptical and very strongly convex outline are characteristic features of *Hadralucina*. The edentulous hinge and very strong convexity suggest *Pegophysema* (*Anodontia* of many authors), but that genus is subglobose and smaller. The type of the type species of *Hadralucina* is moderately large (length 77 mm). The largest specimen in USNM collections—like the type, an internal mold of articulated valves that retain some shell material—was collected in South Carolina (Cooke and MacNeil, 1952, p. 23; USNM 647744). It is more elongate than the type and has a length of 145 mm. My colleague Druid Wilson identified other large specimens from South Carolina (Pooser, 1965, p. 15), which were returned to the collector. All these fossils are of middle Eocene age or are considered to be of that age.

Palmer and Brann (1965, p. 30) assigned to *Anodontia*(?) *augustana* the lucinids shown, as *Loripes subvexa* Conrad, on figures 2 and 4 of Harris, 1919. Harris' specimens, however, are not elongate-subelliptical.

Hadralucina xenica Woodring, n. sp.

Plate 95, figures 6, 9

Shell of moderate thickness, very large, elongate-subelliptical, decidely inequilateral, very strongly convex. Anterior dorsal margin short, slightly convex; posterior dorsal margin elongate, straight. Umbo high, wide, full. Sculpture of irregularly spaced, subdued growth lines. Hinge apparently edentulous. Adductor scars unknown.

Length 115 mm, height 95 mm, convexity (both valves) 90 mm (type).

Type (articulated specimen): USNM 647624.

Type locality: 101j (USGS 24744, West side of Las Cascadas Reach, somewhere between Canal stations 1773 and 1782, Canal Zone), La Boca formation.

This remarkable fossil was picked up loose, by A. A. Olsson and Joanne Allen Stewart, on a berm on the La Boca formation on the west side of Las Cascadas Reach. The articulated specimen retains most of the somewhat corroded shell, part of which is disfigured by hard calcareous matrix. It is more inequilateral than *H. augustana* and the posterior dorsal margin is longer and straight. In an attempt to learn something about the hinge, Olsson sawed the specimen in two. As no hinge was found, it evidently is edentulous.

It is a long gap between middle Eocene and early Miocene, but nothing remotely resembling *H. xenica* has turned up during that interval.

Occurrence: La Boca formation (early Miocene), locality 101j.

Subfamily DIVARICELLINAE

Genus Divaricella von Martens

von Martens, Beiträge zur Meersfauna der Insel Mauritius und der Seychellen; Mollusken, p. 321, 1880.

Type (monotype): *Lucina (Divaricella) angulifera* von Martens, living, Indian Ocean.

The upper part of the Bohio formation on Barro Colorado Island yielded two minute valves of *Divaricella* (length 4 mm). A larger articulated specimen (length 11 mm) from the La Boca formation is in poor condition. Both occurrences are listed as *Divaricella* sp.

Divaricella cf. D. comis Olsson

Plate 116, figures 1, 2

Small, subcircular, moderately convex. Lunule very small, cordate, deeply impressed. Lamellae fairly widely spaced, apex of angle of divarication angular. Right anterior cardinal tooth unrecognizable, right posterior cardinal tooth wide, obscurely bifid. Weak right anterior and posterior lateral tooth. Hinge of left valve and other interior features inaccessible.

Length 10.4 mm, height 9.3 mm, convexity (both valves) 5.9 mm (figured specimen).

Though five valves and two articulated specimens of this small *Divaricella* were found in the middle part of the Gatun formation, the illustrated articulated specimen is the only complete one.

In general features, the fossils from the Gatun are similar to *D. comis* (Olsson, 1964. p. 50, pl. 7, figs. 7–7b; Angostura formation, middle Miocene, Ecuador). Their lamellae, however, are more widely spaced, the right-posterior cardinal tooth is heavier, and the right-lateral teeth are weaker.

Occurrence: Middle part of Gatun formation (middle Miocene), eastern area, localities 139g, 143, 144, 150.

Family FIMBRIIDAE

Genus Fimbria Megerle von Muhlfeld

Megerle von Mühlfeld, Gesellschaft naturforschen der Freunde, Mag. neusten Entdeckungen gesamten Naturkunde, v. 5, p. 52, 1811.

Type (monotype): *Fimbria magna* Megerle von Mühlfeld = *Venus fimbriata* Linné, living, western Pacific and eastern Indian Oceans.

The last species of this ancient genus, more familiarly known as *Corbis*, in America and Europe are of Eocene age. For a treatment of the two living species see Nicol (1950), who resurrected the name *Fimbria*.

Fimbria jamaicensis (Trechmann)

Plate 83, figures 1, 4

Corbis jamaicensis Trechmann, Geol. Magazine, v. 60, no. 710, p. 364, pl. 18, fig. 5, 1923 (Eocene, Jamaica).

Large, elongate-ovate, slightly inequilateral, moderately convex. Concentric sculpture stronger than radial sculpture, which is moderately fine. Interior inaccessible.

Length about 83 mm, height about 67 mm, convexity about 16 mm (figured left valve).

Type: British Museum (Natural History).

Type locality: Spring Mount, St. James Parish, Jamaica, Yellow limestone.

Three more or less incomplete valves, preserved in hard limestone of the Gatuncillo formation are identified as *Fimbria jamaicensis*. The shell material is partly corroded on all. An external mold is also so identified. Though Trechmann cited a length of 55 mm and a height of 40 mm for the type of his species, a topotype (USGS 18706) has the following practically complete dimensions: length 75 mm, height 65 mm.

F. jamaicensis is far larger than any other American species and is more elongate than *F. subpectunculus* (d'Orbigny) (Cossmann and Pissarro, 1904–06, pl. 22, figs. 78–4; Lutetian, Paris basin).

Occurrence: Gatuncillo formation (late Eocene) locality 11. Yellow limestone (middle Eocene), Jamaica.

Fimbria cf. F. vernoni Richards

Plate 83, figures 2, 6

Of medium size, elongate-ovate, inequilateral, anterior end somewhat flattened, strongly convex. Sculpture partly effaced, but concentric sculpture stronger than radial sculpture, which is moderately coarse. Interior inaccessible.

Length 60.4 mm, height 47 mm, convexity about 16 mm (larger figured specimen).

This evidently is a new species, but the three specimens, also found in limestone of the Gatuncillo formation, are internal molds of articulated valves, to which some corroded shell material is attached. The sculpture is shown to best advantage on the posterior part of the smaller illustrated specimen (pl. 83, fig. 2).

The strong convexity is similar to that of *F. vernoni* (Richards, *in* Richards and Palmer, 1953, p. 50, pl. 11, figs. 2–4; late Eocene, Florida). That species, however, is more inequilateral and its radial sculpture is finer.

Occurrence: Gatuncillo formation (late Eocene), locality 9, 12.

Family UNGULINIDAE

Genus Diplodonta Bronn

Bronn, Ergebnisse meiner naturhistorisch öconomischen Reisen, v. 2, p. 484, 1831. Also p. 1x and 96 of separate from that volume issued in same year under title Italiens Tertiär-Gebilde und deren organisch Einschlusse.

Type (logotype, Herrmannsen, Indicis generum malacozoorium, v. 1, p. 392, 1847): *Venus lupinus* Brocchi, 1814, not *Venus lupinus* Linné, 1758, = *Tellina rotundata* Montagu, living eastern North Atlantic Ocean, Oligocene to Pliocene, Italy.

Subgenus Diplodonta s.s.

Diplodonta (Diplodonta) cf. D. alta Dall

Plate 91, figures 14, 15

Of medium size, relatively narrow, vertically ovate, equilateral or almost equilateral, moderately convex. Surface bearing inconspicuous growth lines. Interior inaccessible.

Length 15.5 mm, height 15.3 mm, convexity about 4.5 mm (larger figured specimen).

Diplodonta cf. *D. alta* was collected at three localities in marine lenses in the upper part of the Bohio formation on Barro Colorado Island—a total of 44 specimens, 35 of which are from locality 42f. They range in length from 5 to 15.5 mm. All except some of the smallest lack part of the shell. One valve was found in the Caimito formation on the Panama Railroad.

These Canal Zone fossils are similar in outline and convexity to the type of *D. alta* (Dall, 1890–1903, pl. 11, figs. 9a, 9b, 1890), from the early Miocene Tampa limestone of Florida. When Dall described his species in 1900 on page 1184 of the same publication, he described and illustrated a larger, inequilateral specimen from the Chipola formation, later the type of *D. paralta* Gardner (1926–47, p. 119, pl. 20, fig. 24, 1926). Mansfield's (1937, p. 246, pl. 18, fig. 1) specimen from the Tampa is more circular and more convex than Dall's type.

Occurrence: Bohio formation (late Oligocene), localities 42d, 42f, 42g. Caimito formation, shallow-water facies (late Oligocene), locality 57a.

Diplodonta (Diplodonta) homalostriata Woodring

Plate 113, figures 14–16

Diplodonta (*Diplodonta*) *homalostriata* Woodring, Carnegie Inst. Washington Pub. 366, p. 129, pl. 17, figs. 16, 17, 1925 (Miocene, Jamaica).

Diplodonta sp., Toula, K. k. Geol. Reichsanstalt, Jahrb., v. 58, p. 719, pl. 28, figs. 19a, 19b, 1909 (Miocene, Canal Zone).

Of medium size, vertically ovate, generally slightly inequilateral, anterior end slightly extended, exceptionally almost equilateral; moderately convex. Sculptured, except umbonal part or as much as dorsal half, with very low, closely spaced concentric rugae. Teeth slender. Adductor muscle scars indistinct.

Length (practically complete) 15 mm, height 15.3 mm, convexity about 5 mm (larger figured specimen).

Type (left valve): USNM 352816.

Type locality: Bowden, Jamaica, granule-gravel "shell bed" in Bowden formation.

Diplodonta homalostriata occurs in the lower and middle parts of the Gatun formation. It is represented by 33 valves, all except eight of which are small. Nineteen small valves, one of which is illustrated (pl. 113, fig. 15), were collected at locality 159d.

The concentric sculpture and slightly extended anterior end are diagnostic features of this species. Only three small valves are available from the type locality. The largest (the type) is of about the same size as the illustrated smaller valve from the Gatun.

D. collina (Olsson, 1922, p. 220, pl. 32, fig. 15; middle Miocene, Costa Rica) and *D. insula* (Olsson, 1922, p. 220, pl. 32, fig. 21; late Miocene, Bocas del Toro area, Panamá), possibly one species, have similar concentric sculpture, but their posterior end is extended.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, locality 138e. Middle part, eastern area, localities 139g, 143, 147, 147a, 159d; western area, localities 161, 162a, 169. Bowden formation (middle Miocene), Jamaica.

Diplodonta (Diplodonta) cf. D. minor Dall

Plate 120, figure 14

Minute, obliquely ovate, very inequilateral, anterior end extended, moderately convex. Exterior smooth and polished. Bifid left anterior cardinal tooth heavy for size of shell. Adductor muscle scars not discernible. Right valve unknown.

Length 2.5 mm, height 2.1 mm, convexity about 0.5 mm (figured specimen).

A minute, doubtless immature, left valve from the middle part of the Gatun formation suggests alliance to *Diplodonta minor* Dall (Woodring, 1925, p. 130, pl. 17, figs. 18–21; middle Miocene, Jamaica). The fossil from the Gatun, however, is more smoothly ovate than the Jamaican species; that is, the posterior margin is more arcuate.

Occurrence: Middle part of Gatun formation (middle Miocene), eastern area, locality 159d.

Genus Timothynus Harris

Harris *in* Harris and Palmer, Bull. Am. Paleontology, v. 30, no. 117, pt. 1, p. 86, 1946.

Type (orthotype): *Sphaerella bulla* Conrad, Eocene, Mississippi.

Timothynus capuloides (Gabb)

Plate 115, figure 6

Mysia capuloides Gabb, Am. Philos. Soc. Trans., new ser., v. 15, p. 252, 1873 (Miocene, Dominican Republic).

Diplodonta capuloides (Gabb), Maury, Bull. Am. Paleontology, v. 5, no. 29, p. 207, pl. 39, fig. 1, 1917 (Miocene, Dominican Republic).

Diplodonta (*Sphaerella*) *capuloides* (Gabb), Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 73, p. 419, text-figs. 44a–c, 1922 (Miocene, Dominican Republic).

Diplodonta (*Diplodonta*) *walli* Woodring, Carnegie Inst. Washington Pub. 366, p. 129, pl. 17, figs. 14, 15, 1925 (Miocene, Jamaica).

Minute, globular, umbo moderately high and full. Sculptured with faint, closely spaced concentric striae. Ligament area short, very narrow. Bifid left anterior cardinal tooth heavy for size of shell; thin left posterior tooth fused to edge of nymph. Adductor muscle scars not discernible. Right valve unknown.

Length 2.8 mm, height 2.5 mm, convexity about 1 mm (figured specimen).

Type (right valve): Acad. Nat. Sci. Philadelphia 2694.

Type locality: Dominican Republic, Miocene, probably Cercado formation.

A second minute, doubtless immature, left valve from the same locality as the preceding species is identified as *Timothynus capuloides*. The umbo is not as high or as full as that of mature valves from the Dominican Republic and Jamaica but agrees with immature valves. Mature valves are about twice as large as the minute Canal Zone fossil.

When *Diplodonta walli* was named, only two valves were seen, but seven others are now in collections from the granule-gravel "shell bed" in the Bowden formation.

This is the only known species of *Timothynus* in the Tertiary Caribbean province.

Occurrence: Middle part of Gatun formation (middle Miocene), eastern area, locality 159d. Bowden formation (middle Miocene), Jamaica. Cercado formation (middle Miocene), Dominican Republic.

Family LEPTONIDAE

Genus Temblornia Keen

Keen, San Diego Soc. Nat. History Trans., v. 10, no. 2, p. 38, 1943.

Type (orthotype): *Donax triangulata* Anderson and Martin, Miocene, California.

Temblornia virgata (Gardner)

Plate 115, figures 3, 7, 11, 15

Bornia virgata Gardner, U. S. Geol. Survey Prof. Paper 142, p. 125, pl. 21, figs. 9, 10, 1942 (Miocene, Florida).

Bornia (*Temblornia*) *keenae* Marks, Bull. Am. Paleontology, v. 33, no. 139, p. 71, pl. 4, fig. 3, 1951 (Miocene, Ecuador).

Moderately small, fairly thick shelled, trigonal-ovate, slightly inequilateral, posterior end slightly more extended than anterior; moderately convex. Concentric growth lines inconspicuous. Faint hidden radial markings at both ends near ventral margin; in addition, faint surface radial riblets on lower posterior part of right valve. Hinge and hinge plate of right valve defective. Ventral margin of hinge plate of left valve slightly indented; anterior and posterior cardinal tooth; very slender posterior lateral tooth. Interior ventral margin at both ends radially corrugated.

Length 5.5 mm, height 4.5 mm, convexity about 2 mm (figured right valve).

Type material: Two syntypes (right and left valves) USNM 352494.

Type locality: USGS 3856, 6 miles west-northwest of Mossyhead, Walton County, Fla., Shoal River formation.

The occurrence of *Temblornia* in the lower part of the Gatun formation was noted by Keen and Marks. The illustrated right and left valves and an immature left are the only specimens. Both valves of Florida specimens show faint surface radial sculpture, or corresponding hidden marking, on posterior and anterior ends. As shown by Gardner's illustrations, on the interior of the syntypes, radial undulations extend upward from the ventral marginal corrugations. On the numerous topotypes, the height to which they extend is variable or they are absent.

Bornia fluctusculpturata (Maury, 1910, p. 36, pl. 9, fig. 6; Chipola formation, Florida) is closely related to *T. virgata*, but its exterior radial sculpture is stronger.

Temblornia has been found also in the late Pliocene San Diego formation of California (Hertlein and Grant, 1972, p. 238, text fig. 11).

Occurrence: Lower part of Gatun formation (middle Miocene), localities 136a, 138g. Shoal River formation (middle Miocene), Florida. Subibaja formation (early Miocene), Ecuador.

Family CARDITIDAE

Genus Carditamera Conrad

Conrad, Fossils of the medial Tertiary of the United States, p. 11, 1838.

Type (logotype, Dall, Wagner Free Inst. Sci. Trans., v. 3, p. 1408, 1903): *Carditamera arata* (Conrad) (*Cypricardia arata* Conrad), Miocene, Atlantic coast of United States.

Carditamera has a meager representation in the Culebra, La Boca, and Gatun formations.

Carditamera cf. C. vaughani (Dall)

Of medium size, relatively short, moderately inequiliateral, umbo low. Sculpture of about 16 corroded ribs, wide except on posterior slope. Interior inaccessible.

Length 34 mm, height 23.5 mm, convexity about 12 mm (left valve).

The Culebra formation yielded a left valve in poor condition and a small incomplete right valve, also in poor condition. The relatively short, stubby outline suggests alliance to *Carditamera vaughani* (Dall, 1890–1903, p. 1414, pl. 56, fig. 10, 1903), a late Miocene species from Florida.

Occurrence: Culebra formation (early Miocene), locality 107a.

Carditamera cf. C. tegea (Dall)

Of medium size, narrowly elongate, very inequilateral, umbo low. Sculpture of about 17 narrow ribs, narrower than interribs or of about same width. Interior inaccessible.

Length 24.5 mm, height 15 mm, convexity about 7 mm (left valve).

Four poorly preserved left valves were collected at locality 99b in the La Boca formation. Though the size and outline are similar to those features of *Carditamera tegea* (Dall, 1890–1903, p. 1412, 1903, pl. 11, fig. 4, 1890; Tampa limestone, Florida), the species from the La Boca has narrower ribs. A right valve from locality 115b that is less inequilateral than the left valves, presumably represents the same species.

Occurrence: La Boca formation (early Miocene), Gaillard Cut area, localities 99b, 115b.

Carditamera species

An incomplete right valve of *Carditamera* from the Gatun formation is sculptured with high, wide radial ribs, about twice as wide as the interribs. Though the number of ribs is indeterminable, the total is estimated to be about 15. The interior is inaccessible.

Length (incomplete) 26.5 mm (estimated restored length 30 mm), height (practically complete) 22.5 mm, convexity 11.5 mm (right valve).

Occurrence: Middle part of Gatun formation (middle Miocene), eastern area, locality 144.

Genus Venericardia Lamarck

Lamarck, Système des animaux sans vertèbres, p. 123, 1801.

Type (logotype, Schmidt, Versuch über die beste Einrichtung * * * vorzüglich der Conchylien-Sammlungen * * *, p. 57, 1818 (not seen, quoted from Stewart, 1930, p. 33–35, and Winckworth, 1944): *Venericardia imbricata* Lamarck = *Venus imbricata* Gmelin, Eocene, Paris basin.

Subgenus Rotundicardia Heaslip

Heaslip, Paleontographica Americana, v. 6, no. 39, p. 89, 1968.

Type (orthotype): *Venericardia* (*Rotundicardia*) *rotunda* Lea (*Venericardia rotunda* Lea), Eocene, Alabama.

Venericardia (Rotundicardia) species

Plate 84, figure 2

The silicified fossils from the Río Casaya area include the dorsal part of the left valve of a small *Venericardia*. It is sculptured with 24 low radial ribs, the nodes of which are inconspicuous. The anterior cardinal tooth is heavy for the size of the shell.

Length (practically complete) 13 mm, height (incomplete) 6.3 mm (estimated restored height 10 mm), convexity 5.5 mm (figured left valve).

Molds, for the most part internal molds of articulated specimens, from limestone of the Gatuncillo formation are listed as *Venericardia* sp. They show some indication of sculpture.

Occurrence: Gatuncillo formation (middle and late Eocene), locality 38.

Venericardia (Rotundicardia?) species

Plate 87, figure 14

Small, moderately inequilateral, moderately convex. Sculptured with 25 narrow, closely spaced, conspicuously noded radial ribs. Interior inaccessible.

Length 13.5 mm, height (incomplete) 7 mm (estimated restored height 10 mm), convexity about 5 mm (figured left valve).

The marine rocks of late Eocene age yielded seven valves of a small *Venericardia*. The illustrated left valve is in the best condition. The nodes are much stronger than those of the species from the Gatuncillo.

Occurrence: Marine rocks of late Eocene age, locality 41.

Subgenus Glyptoactis Stewart

Stewart, Acad. Nat. Sci. Philadelphia Spec. Pub. 3, p. 151, 1930.

Type (orthotype): *Venericardia hadra* Dall, Miocene, Florida.

The age range of *Glyptoactis* in the Tertiary Caribbean province is late Eocene to early Pliocene. The earliest species in the western Atlantic part of the province, found in late Eocene deposits in Colombia, is by far the largest (length as much as 58.7 mm). Clark (*in* Clark and Durham, 1946, p. 58, pl. 7, figs. 1, 2, 4, 5, 7–11, 13), who realized he was dealing with a species of *Glyptoactis*, identified it as *Venericardia charanalensis* Olsson, a Peruvian species apparently of the same age. (See Clark's quotation of a communication from Olsson concerning the age.) The identification, however, needs confirmation.

The next largest species (length between 30 and 45 mm), including the following species (p. 628–629) are of Miocene age. Most of the Miocene species and the sole Pliocene species are small (length less than 30 mm). These small species are overnamed: 19 names. The ribs of the Miocene species are terraced or unterraced.

Venericardia (Glyptoactis) metaicha Woodring, n. sp.

Plate 99, figures 15, 19

Moderately large, height slightly less than length, very inequilateral, umbo moderately low, convexity moderately strong. Radial sculpture of 15 to 17 (generally 15) narrow ribs, narrower than interribs. Faint thread forming inconspicuous terrace at base of both sides of some ribs on some specimens. Crest of ribs bearing coarse nodes, on many specimens so greatly worn down that they disappear. Hinge defective or inaccessible.

Length 32 mm, height 29.5 mm, convexity 13.5 mm (type). Length (incomplete) 30.7 mm (estimated restored length 32 mm), height 30 mm, convexity 13.6 mm (paratype).

Type (right valve) USNM 647378; paratype (right valve) USNM 647379.

Type and paratype locality: 116a (USGS 20956, East bank of Panama Canal at Canal Station 2038, near Paraiso, Canal Zone), La Boca formation.

Venericardia metaicha, represented by 33 specimens, ranging in length from 6.8 to 32 mm, occurs in the La Boca formation. The rib nodes are shown to best advantage on the paratype.

This species is characterized by its moderately large size, narrow ribs and correspondingly wide interribs, and low rib count. It is closely related to an unnamed *Glyptoactis* in a Venezuelan collection (USGS 18492, Nodular limestone on Coro road, about 52 km, odometer reading, north of town of Río Tocuyo, Falcón). The Venezuelan form reaches a larger size than the fossils from the La Boca (maximum length about 43 mm), and an incomplete valve shows some terraced ribs. *V. serricosta* (Heilprin) (Heaslip, 1968, p. 113, pl. 27, figs. 7a, 7b, 8, pl. 8, fig. 1), from the early Miocene Tampa limestone of Florida, has the same type of ribbing, but the posterior end of the shell is more elongate than that of *V. metaicha*, and the ribs are completely unterraced.

Occurrence: La Boca formation (early Miocene), Gaillard Cut area, localities 99d, 99f, 99g, 101h, 116, 116a, 119a.

Venericardia (Glyptoactis) stenygra Woodring, n. sp.

Plate 100, figures 4, 7

Moderately large, height less than length, moderately inequilateral, umbo moderately narrow and high, convexity moderately strong, posterior end somewhat depressed. Radial sculpture of 27 closely spaced, strongly noded ribs, twice as wide as interribs, or almost twice as wide. Lunule swollen. Interior inaccessible.

Length (almost complete) 34.6 mm, height 30 mm, convexity (both valves) 23.3 mm (type).

Type (articulated specimen): USNM 647380.

Type locality: 118b (erroneously recorded as 118 on p. 302 of P 306–D) (USGS 23659, West of Panama Canal, overgrown quarry about 250 m west of Borinquin Highway, in line with Canal station 2038, Empire Reach, Canal Zone), type locality of Emperador limestone member of La Boca formation.

In 1960, R. H. Stewart, Geologist of the Panama Canal Company (written commun.), collected the type of *Venericardia stenygra* at the long-lost type locality of the Emperador. The overgrown quarry was soon covered with spoil from widening of the Empire Reach. It is the same locality as 118 (USGS 6016), where in 1911, MacDonald and Vaughan

(Vaughan, 1919, p. 208–209) collected many corals and a few mollusks.

Though the type is the only specimen, and topotypes are unobtainable, this species is named, as the ribbing is distinctive: high count and close spacing. No comparable species has been described.

Occurrence: Emperador limestone member of La Boca formation (early Miocene), Gaillard Cut area, locality 118b.

Venericardia (Glyptoactis) aversa Pilsbry and Johnson

Plate 113, figures 4, 5, 8, 10

Venericardia aversa Pilsbry and Johnson, Acad. Nat. Sci. Philadelphia Proc., v. 69, p. 196, 1917 (Miocene, Dominican Republic). Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 73, p. 415, pl. 45, fig. 10, 1922 (Miocene, Dominican Republic).

Small, narrow, high, height slightly less than length to slightly more than length, very inequilateral, umbo narrow, high; convexity moderately strong. Radial sculpture of 16 to 21 (generally 16 to 19) high narrow ribs, of about same width as interribs. Some ribs weakly terraced on some specimens. Crest of ribs delicately noded. Interribs flat-bottomed, or almost V-shaped, except at anterior and posterior ends of shell, Lunule swollen. Right anterior cardinal tooth reduced; left anterior cardinal tooth very thin.

Length 18.3 mm, height 18.6 mm, convexity 9.7 mm (figured specimen). Length (incomplete) 20.4 mm (estimated restored length 23 mm), height (incomplete) 20.1 mm (estimated restored height 23 mm), convexity (incomplete) 8 mm (estimated restored convexity 10 mm), USNM 647382.

Type: Lectotype, herewith designated, left valve illustrated by Pilsbry, Acad. Nat. Sci. Philadelphia 3215.

Type locality: Dominican Republic, Miocene.

Though this representative of the group of small Miocene species of *Glyptoactis* was collected in the lower and middle parts of the Gatun formation, it is not abundant—a total of 23 specimens, 9 of which are immature.

Venericardia aversa is distinguished by its narrow high outline. The lectotype and a smaller right valve in the Gabb collection are the only known specimens from the Dominican Republic. They are smaller (height 12.5 mm) than the fossils from the Gatun.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, localities 135, 138c. Middle part, eastern area, localities 144, 144d, 147b, 147g, 150, 155, 155a, 155b, 159d. Miocene, Dominican Republic.

Genus Pleuromeris Conrad

Conrad, Am. Jour. Conchology, v. 3, p. 12, 1867.

Type (monotype): *Pleuromeris decemcostata* Conrad, Miocene and Pliocene, Virginia to Florida (generally regarded as a subspecies of *P. tridentata* (Say), which is still living from North Carolina to Florida and the Gulf of Mexico).

Pleuromeris aff. P. acaris (Dall)

Plate 117, figures 11, 13

Very small, obliquely ovate, length and height practically equal, moderately inequilateral, anterior end more extended and margin less convex than posterior end, convexity moderately strong. Radial sculpture of 16 low ribs separated by narrow groove. Rib adjoining anterior margin narrow; two ribs adjoining posterior margin very narrow. Narrow, elongate, closely spaced nodes striking at right angle across ribs. Ribs in umbonal area effaced by wear. Two left cardinal teeth flanking a triangular socket; anterior tooth short, posterior tooth elongate. Right valve unknown.

Length 2.1 mm, height 2.2 mm, convexity about 0.75 mm (figured left valve).

A single left valve from the Gatun formation is similar to *Pleuromeris acaris* (Woodring, 1925, p. 102, pl. 12, figs. 10–12; Miocene, Jamaica). The ribs of the fossil from the Gatun are wider near the ventral margin than on Jamaican specimens at a comparable growth stage.

Occurrence: Middle part of Gatun formation (middle Miocene), western area, locality 169.

Family CHAMIDAE

Genus Chama Linne

Linné, Systema naturae, 10th ed., p. 691, 1758.

Type (logotype, Children, Quart. Jour. Sci. Lit. Arts, v. 15, p. 28, 1823; Internat. Comm. Zoological Nomenclature, Opinion 484, 1957): *Chama lazarus* Linné, living, western Pacific and Indian Oceans.

The generic name *Pseudochama*, which was proposed for species attached by the right valve, is of doubtful validity (Kennedy, Morris, and Taylor, 1970, p. 384–385).

Chama strepta Woodring, n. sp.

Plate 99, figures 16–18

Of medium size, attached by left valve; attachment area small. Left valve vertically ovate, strongly convex. Few left valves show moderately wide, closely spaced, low irregular radial ribs on parts of valve; few others show narrow or very narrow, closely spaced, low riblets on parts of valve. Low irregular concentric undulations on dorsal two-thirds and appressed irregular lamellae on ventral third.

Right valve more rounded than left, moderately to strongly convex. At early stage, right valve sculptured with low, widely spaced concentric lamellae; at late stage, lamellae stronger, more irregular and somewhat foliaceous, at least near ventral margin. Hinge of left valve consisting of massive warped median cardinal tooth and small low posterior lateral tooth. Interior margin smooth. Interior of right valve inaccessible.

Length 39.5 mm, height 54.5 mm, convexity 24.5 mm (type). Length 38.5 mm, height 44.8 mm, convexity 21 mm (largest right valve).

Type (largest left valve): USNM 647410.

Type locality: 115a (USGS 6515, West side of Culbra [Gaillard] Cut, about one-third mile (500 m) north [northwest] of Paraiso, Canal Zone), La Boca formation.

Nineteen valves (13 left and 6 right) of this weakly sculptured species, from the La Boca formation, are available. They range in height from 10 to 39.5 mm. Though none is articulated, left and right valves are associated. The type is the only valve in reasonably good condition.

No comparable species has come to my attention.

Occurrence: La Boca formation (early Miocene), Gaillard Cut area, localities 99g, 99h, 115a, 116a.

Chama berjadinensis F. Hodson

Plate 112, figures 1, 6, 10, 11; plate 113, figures 7, 11, 12

Chama berjadinensis F. Hodson, *in* Hodson, Hodson, and Harris, Bull. Am. Paletontology, v. 13, no. 49, p. 51, pl. 30, figs. 4, 8, 10, pl. 31, figs. 2, 3, 5, 1927 (Miocene, Venezuela).

Chama aff. *berjadinensis* F. Hodson, Jung, Bull. Am. Paleontology, v. 49, no. 223, p. 447, pl. 56, figs. 9, 10, 1965 (Miocene, Venezuela).

Of medium size, attached by left valve; attachment area small. Left valve vertically ovate, generally strongly convex, exceptionally moderately convex. Sculpture of left valve generally dominantly concentric, exceptionally dominantly radial on some small valves. Concentric sculpture of irregularly foliaceous, undulated, irregularly spaced lamellae, subdued or absent on parts of some valves. Radial sculpture irregular, generally interrupted by concentric lamellae, irregularly subdued here and there on some valves. Riblets almost invariably narrow and closely spaced; separated by very narrow groove and scaly or undulated on dominantly radial valves. Some wider ribs present or absent. Right valve more rounded than left; sculpture similar to that of left. Worn spots on both valves reveal finely and regularly sculptured inner layer. Heavy left median cardinal tooth, dorsal side corrugated; small left posterior lateral tooth. Dorsal side of right median socket thickened and corrugated. Interior margin finely fluted.

Length 36 mm, height 51.5 mm, convexity (both valves) 35 mm (larger figured articulated specimen, largest specimen).

Type: Paleontological Research Inst. 22823.

Type locality: North of Urumaco, Falcón, Venezuela, Urumaco formation.

Chama berjadinensis occurs in the lower and middle parts of the Gatun formation: 9 left valves, 9 right, and 3 articulated specimens. The left umbo of the larger illustrated articulated specimen is exceptionally extended. A worn prodissoconch is preserved on a minute right valve (locality 139c).

The worn spots revealing an inner layer of fine regular sculpture and the fluting of the interior margin show that the shell structure is different from that of the preceding species and of the type species of the genus.

On the type and the other valves illustrated by Hodson the sculpture is dominantly radial, whereas on those described by Jung it is dominantly concentric, as it generally is on the fossils from the Gatun.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, localities 138a, 138c. Middle part, eastern area, localities 139c, 139e, 139f, 139h, 155. Cantaure formation (middle Miocene), Falcón, Venezuela. Urumaco formation (middle or late Miocene), Falcón, Venezuela.

Genus Arcinella Schumacher

Schumacher, Essai d'un nouveau système des habitations des vers testacés, p. 217, 1817.

Type (monotype): *Arcinella spinosa* [Schumacher] = *Chama arcinella* Linné, cited in synonymy, living, North Carolina to northern Brasil.

An incomplete mold from the Chagres sandstone is listed as *Arcinella* sp.

Arcinella species

Plate 103, figure 4

Small, length and height practically equal, attached by right valve; attachment area small. Anterior-ventral margin moderately extended; moderately convex. Lunule relatively narrow, moderately depressed, obscurely sculptured. Sculpture of about six low, widely spaced radial ribs, bearing fairly coarse, widely spaced nodes on median part of valve; very narrow, closely spaced, weakly and closely noded, irregular riblets on anterior part; irregular nodes on posterior part. Right cardinal tooth elongate. Left valve unknown.

Length 26.2 mm, height 25.9 mm, convexity 9.5 mm (figured right valve).

A right valve from the La Boca formation near Paraiso (the only specimen) was clumsily repaired but is of interest as an early *Arcinella*. It has more low main ribs than *A. draconis* (Dall) (1890–1903, pt. 6, p. 1399, pl. 56, figs. 17, 18, 1903), from the Chipola formation of Florida. Locklin collected a right and a left valve (USNM 349302) he labelled *Chama draconis* and alleged that they were collected from the Chipola formation at Ten Mile Creek. They were illustrated by Nicol (1952, p. 815, pl. 119, figs. 3–5) as *Pseudochama draconis*. Nicol thought (p. 811) that the locality needed confirmation. As a matter of fact, the locality is unknown. The right valve has stronger "vermicular" secondary sculpture than *Chama draconis*. Gibson-Smith (1979, p. 18) proposed *Nicolia* as a subgenus of *Arcinella*, with *Chama draconis* as the type species. They depended however, on Nicol's illustrations for some of the features of *Chama draconis*. Dall's *Chama draconis* doubtless is an early *Arcinella*. *Nicolia* is regarded as a synonym of *Arcinella*.

Occurrence: La Boca formation (early Miocene), Gaillard Cut area, locality 116a.

Arcinella arcinella (Linne), small form

Plate 112, figures 5, 8, 9, 12

Echinochama antiquata Dall, Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 218, pl. 28, fig. 8, 1922 (Miocene, Costa Rica).

Cf. *Arcinella arcinella* (Linné), Olsson, Neogene mollusks from northwestern Ecuador, p. 52, pl. 38, figs. 3, 3a, 3b, Paleontological Research Inst., 1964 (Miocene, Ecuador).

Arcinella yaquensis (Maury), Jung, Bull. Am. Paleontology, v. 49, no. 223, p. 450, pl. 57, figs. 1, 2, 1965 (Miocene, Venezuela).

Small, height slightly less than length to slightly more than length, depending on variable extension of anterior-ventral margin. Attached by right valve; attachment area small. Both valves strongly convex at maturity. Lunule strongly depressed and sharply delimited or moderately depressed and not sharply delimited, sculptured with low pustules more or less radially alined. Details of sculpture variable. Radial ribs ranging from 7 to 14 (not including short, very narrow intercalated riblets on some valves), of variable width and spacing at maturity; fairly uniform width on immature valves. On mature valves, a strong rib (exceptionally two) present or absent in median part of valve. Ribs bearing short spines; exceptionally few spines extended on some valves; long spines absent. On some narrow ribs, spines replaced by nodes. Interribs pustular. On extreme anterior part of valve, few spiny narrow ribs present or absent, but for most part, sculpture there is pustular; pustules radially alined or not alined. Right cardinal tooth triangular, corrugated or grooved; left cardinal tooth elongate, roughened; interior margin finely fluted.

Length 32.7 mm, height 34 mm, convexity 13 mm (larger figured right valve). Length (incomplete) 35.5 (estimated restored length 37 mm), height (incomplete) 35 mm (estimated restored height 38 mm), convexity 15.5 mm (largest valve).

Type of *Arcinella arcinella:* Museum of Linnean Soc. of London (Hanley, 1855, p. 91).

Type locality: West Indies, living.

This small *Arcinella*, identified as a small form of *A. arcinella*, is common in the Gatun formation. It is represented by 17 specimens from the lower part of the formation, 46 from the middle part, and 6 from the upper part in the eastern area. Right valves are slightly more numerous than left; only one specimen is articulated, and it is incomplete. The height range is 2 to an estimated 38 mm.

The subrectangular, concentrically sculptured early dissoconch is not uncommon: 12 are preserved. As shown by Nicol (1952, p. 815, figs. 5, 7), the early, elongate, concentrically ridged dissoconch of *Chama draconis* (Dall) (see this page, col. 1, of present account; Chipola and possibly Shoal River formations of Florida), which is attached by the right valve, is like that of *Arcinella*. This kind of early dissoconch evidently is unknown in *Chama*. The early dissoconch of *Arcinella antiquata* was erroneously attributed to *Chama involuta* (Woodring, 1925, p. 104, pl. 12, fig. 17).

The contrast in lunular features and some of the contrast in sculpture of the small form of *Arcinella arcinella* are shown by the illustrations. A small living right valve from Puerto Rico (USNM 595405) is very similar to fossils from the Gatun of the style shown on plate 112, figures 5, 9. On an exceptional right valve (locality 149d) the ribs fade out near the ventral margin. Another exceptional right valve (locality 173) has wide interribs, filled with pustules, on the posterior half of the valve.

A. antiquata (Dall) (Woodring, 1925, p. 106, pl. 13, figs. 1–4; Bowden formation, Jamaica) is a large many-ribbed species, whereas *A. yaquensis* (Maury, 1917, p. 201, pl. 33, figs. 11, 12; Cercado and Gurabo formations, Dominican Republic) has low ribs, and its sculpture is dominated by pustules.

Gibson-Smith and Gibson-Smith (1979, p. 14, pl. 3, figs. 11, 12) illustrated as *Arcinella* cf. *A. trachyderma* (Pilsbry and Johnson) a left valve (length 29.4 mm) collected from the middle part of the Gatun formation at Fort Davis in the Canal Zone, near locality 157. It lacks the well-defined lunule of *A. trachyderma.*

Occurrence: Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, localities 138a, 138c, 138d. Middle part, eastern area, localities 139b, 139c, 139e, 155, 155a, 155b, 155c, 157, 159d; western area, localities 161c, 169. Upper part, eastern area, localities 171, 173, 176, 176a. Middle Miocene deposits, Limón Province, Costa Rica. Cantaure formation (middle Miocene), Falcón, Venezuela. Angostura formation (middle Miocene), Ecuador.

Arcinella arcinella (Linne)?

Plate 113, figures 9, 13

Of medium size, height and length generally practically equal, exceptionally height greater than length. Anterior-ventral margin generally slightly to moderately extended, exceptionally barely extended. Attached by right valve; attachment area small. Both valves strongly convex. Lunule generally strongly depressed and sharply delimited, exceptionally slightly depressed and not sharply delimited, generally sculptured with pustules, exceptionally sculptured with undulated or even spiny concentric lamellae. Radial ribs ranging from 7 to 12 (not including short, very narrow intercalated riblets on some valves), generally of variable width and spacing, exceptionally fairly uniform. A strong rib generally present on median part of valve. Ribs bearing short spines, few somewhat extended on some valves; long spines absent. Interribs bearing narrow threads, generally running oblique to ribs, or practically smooth, except for growth lamellae, especially near ventral margin of valve. Right cardinal tooth triangular, grooved; left cardinal tooth elongate, dorsal surface corrugated. Interior margin finely fluted.

Length 46.2 mm, height 46.3 mm, convexity 19.5 mm (larger figured valve, largest specimen).

In the upper part of the Gatun formation in the western area, this *Arcinella* replaces the small form —11 specimens, one of which is articulated. It is larger than the small form and a higher percentage of specimens have a strong rib in the median part. It would be identified as *A. arcinella* were it not for the threads, running oblique to the ribs, in the interribs of some valves on some specimens, especially posterior interribs. The oblique threads are shown on five valves, but three of the remaining six valves are in such condition that they do not show whether oblique threads are present or absent.

A small left valve (length 29.8 mm, height 32.6 mm) from locality 183 accounts for most of the exceptions mentioned in the description. An exception shown by that valve, not mentioned in the description, is that the seven ribs terminate at a growth lamella a little below the midpoint of the height. The remainder of the valve is sculptured with strong, closely spaced, undulated growth lamellae, some of which bear low spines alined with the two anteriormost ribs. The lower edge of most of the lamellae is finely fluted, like the interior margin. For some reason, the normal growth was interrupted.

Occurrence: Upper part of Gatun formation, western area, localities 181, 182, 182a, 183, 185.

Family CRASSATELLIDAE

Genus Bathytormus Stewart

Stewart, Acad. Nat. Sci. Philadelphia Spec. Pub. 3, p. 137, 1930.

Type (orthotype): *Crassatella protexta* Conrad, Eocene, Alabama.

Bathytormus species

Plate 86, figures 4, 5

Small, elongate, sharply carinate. Sculpture of sharp relatively widely spaced concentric lamellae. Interior unknown.

Length (almost complete) 29.5 mm, height (incomplete) 10 mm (estimated restored height 12 mm) (smaller figured specimen). Length 31.3 mm, height 12 mm (larger figured specimen).

Three external molds, from leached sandstone of the Gatuncillo formation capping Cerro Pelado near Gamboa, have the outline and sculpture of *Bathytormus.* Latex impressions of the one that shows the sculpture to best advantage and of another that has the best outline are illustrated.

This species is smaller and more sharply carinate than Paleocene and Eocene species from eastern and southeastern United States, and its lamellae are sharper and more widely spaced. The same features of carina and lamellae distinguish it from *B. juanadiazus* (Maury, 1920, p. 27, pl. 4, figs. 6, 7; Oligocene, Puerto Rico), the only other species from the Tertiary Caribbean province on record.

Occurrence: Gatuncillo formation (late Eocene), locality 37a.

Genus Eucrassatella Iredale

Iredale, Linnean Soc. New South Wales Proc., v. 49, p. 202, 1924.

Type (orthotype): *Crassatella kingicola* Lamarck, living, Australia.

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Subgenus Eucrassatella s.s.

Eucrassatella (Eucrassatella) mediamericana (Brown and Pilsbry)

Plate 99, figures 1, 6

Crassatella mactropsis (Conrad), Gabb, Acad. Nat. Sci. Philadelphia Jour., 2d ser., v. 8, p. 345, pl. 44, fig. 20, 1881 (Miocene, Costa Rica).

Crassatellites mediamericanus Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 64, p. 515, pl. 25, figs. 3–5, 1913 (Miocene, Costa Rica, Canal Zone).

Of medium size, moderately inequilateral, umbo not flattened. Posterior slope carinate, carina generally of practically equal strength throughout; exceptionally disappearing near ventral margin. Slight depression in front of carina, faintly insinuating ventral margin. Lunule and escutcheon not preserved or not accessible. Sculpture of low, fairly closely spaced concentric lamellae. Interior inaccessible.

Length about 46 mm, height about 31 mm, convexity about 10 mm (larger figured specimen, largest specimen).

Type material: Lectotype, herewith designated: larger valve illustrated by Brown and Pilsbry, Acad. Nat. Sci. Philadelphia 3498.

Type locality: Gabb's lost Sapote [Zapote] locality on Río Reventazón, northeastern Costa Rica, deposits of early Miocene age.

The La Boca formation yielded a small sample of a *Eucrassatella* identified as *E. mediamericana*: seven valves, four of which are immature and none of which is as large as the lectotype. The contrast in persistence and disappearance of the carina is shown by the illustrations of two valves collected at the same locality. Figure 5 of Brown and Pilsbry's illustrations represents a specimen from the La Boca at their "*Pecten* bed" locality in the Las Cascadas Reach of the Canal. (For the stratigraphic position of their "*Pecten* bed" see p. 587 of present account). This specimen is more elongate than USNM specimens.

E. mediamericana is somewhat similar to a species now ranging from North Carolina to Florida, the Gulf of Mexico, and Campeche Bay. The earliest name for it is *Crassatella speciosa* A. Adams (Lamy, 1916, p. 219). The concentric lamellae of mature shells of that species are more closely spaced than those of the fossils from the La Boca. The living species extends back to the upper Miocene, at which level it was named *Crassatella gibbsii* by Tuomey and Holmes.

Occurrence: La Boca formation (early Miocene), Gaillard Cut area, localities 99f, 101h, 116a, 119. Deposits of early Miocene age, northeastern Costa Rica.

Eucrassatella (Eucrassatella) species

Plate 116, figure 14

Height of immature valves moderately less than length to decidely less than length, moderately inequilateral. Low rounded carina on posterior slope. Slight depression, slightly insinuating ventral margin, in front of carina on ventral part of valve. Lunule moderately narrow, deeply depressed, escutcheon narrow. Umbo flattened. Umbo and adjoining dorsal part of valve sculptured with coarse concentric waves, remainder of valve, except posterior slope behind carina, sculptured with low, closely spaced concentric lamellae. Hinge of left valve, as usual, consisting of two anterior cardinal teeth and a long, shallow posterior depression, to receive edge of right valve.

Length 27.5 mm, height 20.8 mm, convexity 6.2 mm (figured left valve, largest specimen).

Four small immature left valves were found in the middle part of the Gatun formation. They may represent the same species as Olsson's Costa Rican *Eucrassatella reevei* (Gabb) (Olsson, 1922, p. 212, pl. 20, fig. 4). It is doubtful, however, whether the Costa Rican fossils are *E. reevei* (Brown and Pilsbry, 1913, p. 515, pl. 24, fig. 5, not pl. 23; Miocene, Dominican Republic).

Occurrence: Middle part of Gatun formation (middle Miocene), locality 155b.

Subgenus Hybolophus Stewart

Stewart, Acad. Nat. Sci. Philadelphia Spec. Pub. 3, p. 139, 1930.

Type (orthotype): *Crassatella gibbosa* Sowerby, living, Gulf of California to Paita, northern Perú.

The species of *Hybolophus* may be divided into two groups: high and elongate. No sharp discontinuity between the two groups is apparent. The type species itself is more or less intermediate but is classified in the elongate group. The only species surviving in the western Atlantic Ocean—*Eucrassatella antillarum* (Reeve)—is a member of the high group. The elongate group is characteristic of the Miocene Caribbean province. Species of that group have been found in the Miocene of Trinidad, Venezuela, Colombia, Panamá, Ecuador, and Perú. It is a paciphile group.

Group of elongate species

Eucrassatella (Hybolophus) elassa Woodring, n. sp.

Plate 116, figure 7; plate 117, figures 14, 18

Moderately small, elongate, ratio of height to length somewhat variable (height 65 to 69 percent of length), median part of valve strongly convex. Posterior end extended and attenuated. Rounded carina near posterior dorsal margin. Anterior margin strongly convex, posterior dorsal margin concave, ventral margin convex, generally widely and shallowly insinuated in front of rounded carina. Lunule moderately narrow, shallow or moderately depressed, escutcheon narrow. Umbo flattened. Umbo and adjoining dorsal part of valve sculptured with relatively coarse, widely spaced concentric waves. Fine, closely spaced, low concentric lamellae on anterior part of valve; exceptionally extending farther posteriorly, even to carina, replaced on carina and narrow posterior slope by low growth lamellae. Two cardinal teeth in each valve and a left long shallow posterior depression, to receive edge of right valve.

Length 43 mm, height 28 mm, convexity (both valves) 22.6 mm (type). Length (incomplete) 42.5 mm (estimated restored length 47 mm) (dorsal fragment, largest specimen).

Type (articulated): USNM 647424.

Type locality: 138a (Stanford Univ. 2656, latitude 9°21′ N., plus 5,000 feet (1,525 m), longitude 79°50′ W., plus 1,000 feet (300 m), Panamá; same as 138, USGS 16909), lower part of Gatun formation.

This elongate species is characteristic of the lower part of the Gatun formation. About 300 specimens were collected in that part, including 220 in two collections from the same locality near Cativa, Panamá (138c and 138d). Right valves barely outnumber left; only 15 specimens are articulated. The length ranges from 6.5 to an estimated 47 mm. Prodissoconchs are preserved on four minute left valves (locality 138). Some variation in the ratio of height to length and in the extent of the valve bearing fine sculpture is apparent.

Eucrassatella elassa is closely related to *E. berryi* (Spieker) (1922, p. 131, pl. 7, figs. 9, 10; Olsson, 1932, p. 85, pl. 6, figs. 2, 8; early Miocene, Perú). The Peruvian species, however, has a higher ratio of height to length and coarser sculpture. *E. berryi telemba* (Olsson, 1964, p. 42, pl. 5, figs. 7, 7a; middle Miocene, Ecuador) is the most elongate of the elongate forms and its sculpture is coarser than that of the nominate subspecies. Perhaps it is to be given specific rank.

Occurrence: Lower part of Gatun formation (middle Miocene), localities 136, 136a, 137a, 138, 138a, 138c, 138d, 138f, 138g, 138h.

Eucrassatella (Hybolophus) venezuelana (F. Hodson)

Plate 116, figure 21; plate 117, figure 19

Crassatellites trinitarius venezuelanus F. Hodson,*in* Hodson, Hodson, and Harris, Bull. Am. Paleontology, v. 13, no. 49, p. 45, pl. 28, figs. 2, 6, 9, 1927 (Miocene, Venezuela).

Crassatella (Eucrassatella) trinitaria venezuelana (F. Hodson), Barrios, Colombia Servicio Geol. Nac., Bol. Geol., v. 6, nos. 1–3 (Informe 1082), p. 245, pl. 5, figs. 1, 2, 1960 (Miocene, Colombia).

Eucrassatella trinitaria venezuelana (F. Hodson), Jung, Bull. Am. Paleontology, v. 49, no. 223, p. 443, pl. 55, fig. 5, pl. 56, figs. 1, 2, 1965 (Miocene, Venezuela). Diaz de Gamero, Univ. Central de Venezuela, Geos, no. 17, p. 35, 1968 (Miocene, Venezuela).

Resembling preceding species, but ratio of height to length higher (height 72 percent of length). Posterior end not as strongly attenuated.

Length 45.3 mm, height 33 mm, convexity (both valves) 24.5 mm (figured articulated specimen).

Type: Paleontological Research Inst. 21999.

Type locality: South of Butare, Falcón, Venezuela. Formation and age not specified.

In the middle part of the Gatun formation and in the upper part in the western area, *Eucrassatella elassa* is replaced by *E. venezuelana*. Only one specimen was found in each area; that in the upper part of the formation was smaller (length 34 mm) than the illustrated specimen from the middle part.

The type of *E. trinitaria* (Maury, 1925a, p. 175, pl. 31, figs. 1, 7), which is from the Savaneta glauconitic sandstone member of the Springvale formation, and the topotypes are barely carinate, and their convexity is less than that of *E. venezuelana*. To be sure, the larger illustrated valve of *E. trinitaria* from the Melajo clay member of the Springvale formation (Jung, 1969, p. 351, pl. 21, figs. 1, 2) is more distinctly carinate than the typical form. It retains, however, the slight convexity of that form.

Occurrence: Middle and upper parts of Gatun formation (middle Miocene). Middle part, eastern area, locality 155. Upper part, western area, locality 182. Piojó and Tubará formations (middle Miocene), Atlántico, Colombia. Middle Miocene deposits, including Caujarao and Cantaure formations, Falcón, Venezuela. Usiacurí formation (late Miocene), Atlántico, Colombia. El Veral formation (late Miocene), Falcón, Venezuela.

Genus Crassinella Guppy

Guppy, Geol. Magazine, decade 2, v. 1, p. 442 (list), 1874.

Type (monotype): *Crassinella Martinicensis* (d'Orbigny) (*Crassatella martinicensis* d'Orbigny), living, Caribbean region.

Harry (1966, p. 67–69), fully documented the nomenclatorial jungle surrounding *Crassinella*, including my erroneous interpretation (Woodring, 1925, p. 96).

Crassinella martinicensis (d'Orbigny)?

Plate 116, figures 3, 4, 8

Small, subtriangular, ratio of height to length variable, generally slightly inequilateral (posterior end slightly more extended than anterior end); exceptionally equilateral. Anterior dorsal margin generally slightly convex; exceptionally straight. Posterior dorsal margin generally slightly to barely concave in umbonal area; exceptionally practically straight. Ventral margin strongly convex. Umbo pointed. Lunule, as well as escutcheon, linear, both slightly depressed. Sculpture generally of widely spaced low concentric lamellae or rounded swellings; exceptionally, more numerous and more closely spaced; exceptionally, sculpture absent on part of shell, or even on entire shell. Hinge of right valve: two cardinal teeth, both in front of chondrophore, posterior one slightly wider than anterior; long, fairly deep anterior groove, to receive edge of left valve. Hinge of left valve: two cardinal teeth flanking triangular chondrophore, posterior one longer than anterior; long, deep posterior groove, to receive edge of right valve; exceptionally short, shallow anterior groove far down.

Length 4.1 mm, height 3.5 mm (left valve, largest figured specimen, largest specimen).

The Miocene species of *Crassinella* in eastern United States and the Tertiary Caribbean province are plagued with a plethora of names, just as Harry found the species living in the western Atlantic Ocean to be plagued, except that far more names are available for the fossils (23 names for species and subspecies).

Crassinella occurs in the lower and middle parts of the Gatun formation. The 32 specimens are presumed to represent one species—a very variable species in outline and sculpture. The greatest range in variability is afforded by 18 specimens from the lower part of the Gatun at locality 138c, the only collection consisting of more than three specimens. The sculpture ranges from the prevailing pattern of widely spaced lamellae, or swellings, covering the entire shell (like that shown on pl. 116, fig. 4, a specimen from a middle Gatun locality) to suppression of sculpture on parts of the shell, to complete loss of sculpture (pl. 116, fig. 8). That is, these fossils run the same sculptural gamut as that described by Harry (1966, p. 72–73) for dredged specimens of the basically northern *C. lunulata*. A middle Gatun valve (pl. 116, fig. 3) is the only one that has numerous, more closely spaced lamellae.

D'Orbigny described two living species in the Caribbean region: *C. martinicensis* (d'Orbigny, 1842–1853(?), p. 288, 1853(?), pl. 27, figs. 21–23, 1842) and *C. guadalupensis* (d'Orbigny, 1842–1853(?), p. 289, pl. 27, figs. 24–27, 1853(?)). Despite the difference in size shown by his figures 23 and 26 (height 2.5 mm for *C. martinicensis* and 7 mm for *C. guadalupensis*), it remains to be seen whether two species are living there. Harry (1966, p. 71) synonymized *C. guadalupensis* with *C. lunulata*, evidently chiefly on the basis of size.

The identification of the fossils from the Gatun as *C. martinicensis* (?) is a compromise, if not a subterfuge; in any event it is time-saving.

Occurrence: Lower and middle parts of Gatun formation (middle Miocence). Lower part, localities 138, 138a, 138c. Middle part, eastern area, localities 139c, 147b, 147g, 155a; western area, 169.

Family CARDIIDAE

Subfamily CARDIINAE

Genus Schedocardia Stewart

Stewart, Acad. Nat. Sci. Philadelphia Spec. Pub. 3, p. 255, 1930.

Type (orthotype): *Cardium hatchetigbeense* Aldrich, Eocene, Alabama.

Schedocardia? species

Plate 83, figure 8

Of medium size, height slightly greater than length, practically equilateral, strongly convex. Umbo narrow. About 22 moderately wide ribs, of about same width as interribs. Ribs obscurely roughened. Interior unknown.

Length 35 mm, height 39 mm, convexity about 16 mm (figured right valve). Length (incomplete) 50.5 mm (estimated restored length 53 mm), height (practically complete) 56 mm, convexity about 22 mm (largest specimen).

Sixteen specimens from limestone of the Gatuncillo formation are doubtfully assigned to *Schedocardia*. Though they are molds, for the most part molds of articulated valves, they retain traces, or more than traces, of the ribs. The narrow umbo suggests that this species is not a typical *Schedocardia*.

Occurrence: Gatuncillo formation (late Eocene), localities 9, 11, 12.

Schedocardia? gatunensis samanica (Olsson)

Plate 83 figures 3, 5

Cardium (Trigoniocardia) samanicum Olsson, Bull. Am. Paleontology, v. 14, no. 52, p. 32, pl. 11, fig. 2, 1928 (Eocene, Perú).

Schedocardia juncea (Olsson), Clark, *in* Clark and Durham, Geol. Soc. America Mem. 16, p. 62, pl. 5, figs. 2, 3, 5, 1946 (Eocene, Colombia).

Fragum (Trigoniocardia) bolivarensis Clark, *in* Clark and Durham, Geol. Soc. America Mem. 16, p. 62, pl. 5, fig. 4, not fig. 6, 1946 (Eocene, Colombia).

Of medium size, height generally less than length, slightly inequilateral, moderately convex. Umbo moderately wide. Posterior slope flattened behind a rib generally slightly higher than others. Nine to 13 ribs in front of and including slightly higher rib; about 5 or 6 on posterior slope. Ribs moderately wide and of about same width as interribs, or wider and wider than interribs. Median part of ribs bearing beads or low spines, worn off on some ribs, or entire rib noded. More or less distinct shallow median groove on ribs that lack beads on well preserved specimens. Interior unknown.

Length (incomplete) 28 mm (estimated restored length 35 mm), height (almost complete) 25.5 mm, convexity about 10 mm (larger figured left valve).

Type: Paleontological Research Inst. 3586.

Type locality: Casa Samán, 10 miles (16 km) northwest of Sullana, Piura Department, Perú Samán formation.

The best preservation of this cardiid is afforded by eight incomplete external molds from the sandstone of the Gatuncillo formation capping Cerro Pelado. Ten molds from limestone at locality 11 are poorly preserved, deformed, and coarsely sculptured.

The flattened posterior slope and the slightly higher rib generally setting off the slope produce a somewhat fragine-like outline, unlike the outline of the type species of *Schedocardia*. On Peruvian specimens the posterior slope is slightly concave, but the higher rib is not as conspicuous as on the largest fossils from the Gatuncillo.

In Perú *S. gatunensis samanica* occurs in the late Eocene Samán formation. (Its relations to the nominate subspecies are discussed under the next heading.) *S.? juncea* (Olsson, 1930, p. 25, pl. 2, figs. 4, 10), of the late Eocene Talara formation, which is somewhat older than the Samán, is smaller and less fragine-like.

Occurrence: Gatuncillo formation (late Eocene), localities 11, 37a. Samán formation (late Eocene), Piura, Perú. Late Eocene part of Carmen formation, Bolívar, Colombia.

Schedocardia? gatunensis gatunensis (Dall)

Plate 87, figure 8

Cardium (*Fragum*) *gatunense* Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 5, p. 1100, 1900 (Eocene, Canal Zone). Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc. v. 63, p. 368, 1911 (Dalls record).

Not *Cardium* (*Trachycardium*) *gatunense* Toula, K. k. Geol. Reichsanstalt Jahrb., v. 58, p. 720, pl. 27, fig. 4, pl. 28, fig. 18, 1909 (Miocene, Canal Zone).

Of medium size, height slightly greater than length, slightly inequilateral, moderately convex. Umbo moderately wide. Posterior slope more or less flattened behind a rib slightly higher than others. Thirteen or 14 ribs in front of and including slightly higher rib; about 9 on posterior slope. Ribs on posterior slope generally beaded. Part of few ribs on main part of valve exceptionally beaded. Sides of ribs on main part of valve minutely nicked or beaded on well-preserved ribs. Interior inaccessible.

Length 23 mm, height 24.7 mm, convexity 14.5 mm (lectotype).

Type material: Lectotype, right valve, herewith designated, USNM 135241.

Type locality: 40a (USGS 2683, Vamos Vamos, Canal Zone), marine rocks of late Eocene age.

The trivial name of Dall's unillustrated species suggests that it was found in the Gatun formation. As a matter of fact, the type lot of eight specimens was collected by R. T. Hill at the submerged Vamos Vamos locality. *Schedocardia? gatunensis gatunensis*, like *Samancetia samanensis* (p. 517 of P306–E), is characteristic of the so-called marine rocks of late Eocene age. It is represented by some 40 valves, most of which are in poor condition because of the tough matrix of the calcareous concretions enclosing them. The range in length is 4 to 23 mm.

The smaller size of the nominate subspecies is the most obvious difference between it and *S.? gatunensis samanica*. In addition, the nominate subspecies has a few more ribs on the posterior slope. The outline of both is somewhat fragine-like, which led Dall to assign his species to *Fragum*. Perhaps these early Tertiary forms are to be assigned to a new subgenus or genus, but that action should not be taken without knowledge of the hinge.

Occurrence: Marine rocks of late Eocene age, localities 40a, 40b, 40d, 41, 41b.

Subfamily TRACHYCARDIINAE

Genus Trachycardium Morch

Mörch, Catalogus conchyliorum * * * Comes de Yoldi, pt. 2, p. 34, 1853.

Type (logotype, von Martens, Zool. Record, 1869, p. 586, 1870): *Cardium isocardia* Linné, living, West Indies and Caribbean Sea, Panamá to Trinidad.

Cardium durun Brown and Pilsbry (1913, p. 516, pl. 24, fig. 6, not pl. 23), corrected to *C. durum* by Pilsbry (1922, p. 420) is unrecognizable. The type, and only specimen, is a badly corroded right valve from the middle part of the Gatun formation. It probably is *Trachycardium stiriatum* (p. 640).

Trachycardium? species

Limestone of the Gatuncillo formation at locality 12 yielded six internal molds of a cardiid that suggests *Trachycardium*. Traces of the ribs show that they are numerous, narrow, and separated by a groove.

Length (incomplete) 32 mm (estimated restored length 38 mm), height 40 mm, convexity about 23 mm (largest specimen).

These molds are associated with the molds identified as *Schedocardia*? sp.

Occurrence: Gatuncillo formation (late Eocene), locality 12.

Subgenus Trachycardium s.s.

Trachycardium (Trachycardium) cf. T. (T.) isocardia (Linne)

Plate 98, figure 1

Large, height slightly less than length to slightly more than length, moderately inequilateral, strongly convex. Umbo of moderate width. Sculpture of 34 to 42 ribs (generally under 40), almost twice as wide as interribs, except on posterior slope, where ribs and interribs are of about equal width. Outer shell layer missing, but base of vaulted scales, open adventrally, more or less preserved on ribs, especially ventral part of posterior and anterior ribs. Hinge inaccessible.

Length 52 mm, height (not quite complete) 50.5 mm, convexity about 18 mm (figured left valve, largest specimen).

The description is based on 30 specimens from the La Boca formation. Though these fossils are wider and more inequilateral than *Trachycardium isocardia*, the sculptural pattern is similar. A similar pattern is shown by *T. pessoae* (Maury, 1925b, p. 307, pl. 17, figs. 15, 18; early Miocene, Brasil).

An immature, subcircular left valve (length 22.6 mm), from the upper part of the Gatun formation in the western area at locality 182, is a preserved shell. It is sculptured with 37 narrow ribs separated by very narrow interribs. Vaulted scales embellish anterior and posterior ribs and the ventral part of median ribs. Though the cardinal teeth are missing, it can be seen that the anterior lateral teeth are closer than the posterior lateral teeth to the cardinal teeth. The ribs are narrower than those of the species from the La Boca at the same growth stage and much narrower than those of *T. isocardia*.

A dental wax impression of the external mold of an incomplete valve of *Trachycardium* of moderate size (incomplete length and height 32 mm) is available in the collection from the Toro limestone member of the Chagres sandstone at locality 196. The impression was made many years ago, and the mold itself evidently was discarded. All 25 ribs bear vaulted scales. These two specimens are listed as *T.* cf. *T. isocardia*, without implying that they represent the same species as that from the La Boca.

Occurrence of species from La Boca formation (early Miocene): Gaillard Cut area, localities 99f, 99g, 101h, 119, 119a, 119c.

Subgenus Dallocardia Stewart

Stewart, Acad. Nat. Sci. Philadelphia Spec. Pub. 3, p. 264, 1930.

Type (orthotype:) *Cardium quadragenerium* Conrad, living, Santa Barbara, Calif. to Todos Santos Bay, Baja California.

Trachycardium (Dallocardia) phlyctaena (Dall)

Plate 98, figures 4, 8

Cardium (*Cerastoderma*) *phlyctaena* Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 5, p. 1097, 1900; pt. 6, pl. 48, fig. 13, 1903 (Miocene, Florida). Dall, U. S. Natl. Mus. Bull. 90, p. 144, pl. 25, fig. 10, 1915 (Miocene, Florida).

Cardium (*Trachycardium*) *phlyctaena* Dall, Mansfield, Florida Dept. Conservation Geol. Bull. 15, p. 253, 1937 (Miocene, Florida).

Of medium size, height slightly greater than length, slightly inequilateral, moderately convex. Sculpture of 25 to 38 ribs (generally 25 to 28), about twice as wide as interribs. At least some ribs generally more or less distinctly noded; nodes presumably base of eroded low scales. Hinge unknown.

Length (incomplete) 33.8 mm (estimated restored length 36 mm), height (practically complete) 37.6 mm, convexity about 13 mm (larger figured valve).

Type: USNM 157570.

Type locality: Ballast Point, Tampa Bay, Fla., Tampa limestone.

Though *Trachycardium phlyctaena* is fairly common in the La Boca formation (45 valves), it also occurs in the Culebra formation (19 valves) and the lower member of the Alhajuela formation (2 valves), and doubtfully in the Bohio formation (a small valve). These fossils are not well preserved, and some are deformed. They reach a larger size in the La Boca than in the other formations.

As identified in the Canal Zone, the species shows a considerable range of variation, not only in the number of ribs, but also in the width of ribs and interribs. The bulk of the fossils have ribbing like that of the larger illustrated valve (pl. 98, fig. 8). The smaller illustrated valve (pl. 98, fig. 4) has an exctpionally large number of ribs (about 38) and exceptionally narrow interribs. The ribs of a valve from the Culebra are wider than usual. The type has a length of 26 mm, whereas the length of a topotype (USNM 157576) is 35.8 mm.

The ribs of *T. zorritense* (Spieker, 1922, p. 134, pl. 7, fig. 12; early Miocene, Perú) are higher and those on the posterior slope are divided.

Occurrence: Bohio formation (late Oligocene), locality 42i (identification doubtful). Culebra formation (early Miocene), localities 106, 111b. La Boca formation (early Miocene), Gaillard Cut area, localities 99c, 99d, 99g, 101, 114, 115, 115a, 116a, 119b, 119c. Lower member of Alhajuela formation (early Miocene), locality 79. Tampa limestone (early Miocene), Florida.

Trachycardium (Dallocardia) cf. T. (D.) dominicense (Gabb)

Plate 90, figures 15, 16

Of medium size, height generally slightly less than length, slightly inequilateral, strongly convex. Sculpture of 32 to 36 strong narrow ribs, separated by very narrow interribs; posterior slope not ribbed or faintly ribbed. Well-preserved ribs faintly noded. Hinge unknown.

Length 25.9 mm, height 26 mm, convexity about 12 mm (larger figured valve).

Twenty-four specimens of this *Trachycardium* were found in marine lenses in the upper part of the Bohio formation on Barro Colorado Island, all except three at locality 42d, and only one of which is articulated. It may be a small predecessor of *T. dominicense*, the following species, although the posterior slope of that species is strongly ribbed. The ribs and interribs are narrower than those of *T. phlyctaena*, with the exception of the narrow interribs of the smaller illustrated specimen of that species (pl. 98, fig. 4) and of other specimens from that locality.

Occurrence: Bohio formation (late Oligocene), localities 42d, 42g.

Trachycardium (Dallocardia) dominicense dominicense (Gabb) small form

Plate 99, figures 2, 3

Moderately large, height slightly greater than length, slightly inequilateral, strongly convex. Sculpture of 36 to 49 (generally more than 40) narrow ribs, separated by very narrow interribs, so narrow that on valves that have some of outer shell layer preserved, interribs are narrow grooves. Six to 14 (generally about 10) divided ribs on posterior slope. Minor sculpture effaced on all except few valves showing low nodes on ventral part of some ribs, presumably base of small prickles. Lunular area not preserved. Hinge unknown.

Length 37.8 mm, height 44.2, convexity about 15 mm (larger figured specimen).

Like *Aequipecten canalis* (p. 591), the small form of *Trachycardium dominicense dominicense* is preeminently characteristic of the La Boca formation. Also like the scallop, it is especially abundant in the Tower N area and at locality 101h, both in the Las Cascadas Reach. (For the location of the pre-Canal Tower N area see p. 587). Most of the 155 specimens from the La Boca are isolated valves, but all except 13 of the 41 from locality 101h are articulated. Also, most of these fossils are in the condition shown by the larger illustrated specimen (pl. 99, fig. 3); that is, the outer shell layer is dissolved. It is at least partly preserved on a few, like the smaller illustrated specimen (pl. 99, fig. 2), which is laterally shortened by crushing.

The relations of this small form to the typical form are mentioned under the next heading.

Occurrence: La Boca formation (early Miocene), Gaillard Cut area, localities 99a, 99b, 99c, 99d, 99f, 99g, 99h, 100b, 101h, 119a, 119b, 119c, 120. Emperador limestone member of La Boca formation (early Miocene), Gaillard Cut area, locality 117a (identification doubtful); Madden basin, localities 71 (identification doubtful), 73. Upper member of Alhajuela formation (early Miocene), locality 86.

Trachycardium (Dallocardia) dominicense dominicense (Gabb)

Plate 114, figures 10, 11, 14

Cardium (*T.* [*rachycardium*] *dominicense* Gabb, Am. Philos. Soc. Trans., v. 15, p. 250, 1873 (Miocene, Dominican Republic).

Cardium (*Trachycardium*) *dominicense* Gabb, Gabb, Acad. Nat. Sci. Philadelphia Jour., 2d ser., v. 8, p. 344, 1881 (Miocene, Costa Rica). Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 63, p. 367, 1911 (Miocene, Canal Zone). Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 73, p. 421, pl. 25, figs. 8, 9, 1922 (Miocene, Dominican Republic). Anderson, California Acad. Sci. Proc., 4th ser., v. 8, p. 164, 1929 (Miocene, Colombia).

Cardium dominicense Gabb, Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 225 (assigned to subgenus *Trachycardium*), pl. 27, fig. 2, 1922 (Miocene, Costa Rica, Canal Zone).

Trachycardium (*Trachycardium*) *dominicense* (Gabb), Olsson, Neogene mollusks from northwestern Ecuador, Paleontological Research Inst., p. 53, pl. 6, figs. 1, 1a, 1964 (Miocene, Ecuador).

Cardium (*Trachycardium*) *gatunense* Toula, K. k. Geol. Reichsanstalt Jahrb., v. 58, p. 720, pl. 27, fig. 4, pl. 28, fig. 18, 1909 (Miocene, Canal Zone). Not *Cardium* (*Fragum*) *gatunense* Dall, 1900.

Similar to small form of *Trachycardium dominicense dominicense*, but larger and rib count almost consistently higher (49 to 56, generally some 50). Well-preserved valves show slightly concave, smooth (except for inner growth lamella) lunular area;

diagonally elongate prickles on posterior limb of divided ribs on posterior slope; and minute prickles or swellings on extreme anterior ribs and on ventral part of adjoining ribs. Right anterior cardinal tooth small, anterior lateral teeth closer to cardinal teeth than posterior lateral teeth.

Length 51.5 mm, height 62.8 mm, convexity (both valves) 48.7 mm (larger figured specimen, largest specimen).

Type: Left valve figured by Pilsbry, see explanation of this plate, Acad. Nat. Sci. Philadelphia 2764.

Type locality: Dominican Republic, Miocene.

The typical form of *T. dominicense dominicense* is widespread and locally common in the middle part of the Gatun formation but is notably absent in other parts of the formation. Most of the 80 specimens, like the larger illustrated one (pl. 114, fig. 10), lack the outer shell layer; in fact, on some, all, or practically all, of the shell is dissolved. Three valves and a fragment, however, are well-preserved shells. The largest complete shell is illustrated (pl. 114, figs. 11, 14). Almost half of these fossils are articulated.

The type and a small left vaive, both collected by Gabb, are the only known specimens from the Dominican Republic. The type evidently is immature (length 38 mm, estimated height 44 mm). The large number of ribs (about 54), however, indicates that it is the form that reaches a larger size than the type in the Canal Zone and elsewhere.

Occurrence: Middle part of Gatun formation (middle Miocene), eastern area, localities 139g, 141, 143, 144, 144a, 145, 147, 147a, 147b, 147c, 147d, 147g, 151, 153, 153a, 155, 155b, 158, 159, 159d; western area, localities 160, 161, 161a, 165, 169. Deposits of early Miocene age at Sapote [Zapote], northeastern Costa Rica (Gabb's record). Miocene, Dominican Republic. Deposits of middle Miocene age, Limón Province, Costa Rica. Miocene, Colombia (Anderson's record). Angostura formation (middle Miocene), Ecuador.

Trachycardium (Dallocardia) dominicense hadratatum Woodring, n. subsp.

Plate 116, figures 27, 28

Similar to typical form of nominate subspecies, but larger and rib count consistently higher (61 to 66). On some valves, small prickles on ventral part of anterior and median ribs, in addition to elongate prickles on posterior slope.

Length (incomplete) 57 mm (estimated restored length 65 mm), height 68 mm, diameter about 37 mm (right valve of articulated type).

Type (articulated specimen, valves rotated): USNM 647469; paratype (articulated specimen): USNM 647470.

Type locality: 182a (USGS 8488, Caribbean coast east of San Miguel [Río Miguel], station 25 plus 400 feet (120 m), Panamá), upper part of Gatun formation; paratype locality: 185 (USGS 8383, Caribbean coast, west of Río San Miguel [Río Miguel], station 26 plus 100 feet (30 m), Panamá), upper part of Gatun formation.

This very large subspecies of *Trachycardium dominicense* is based on five specimens (three articulated) and two fragments from the upper part of the Gatun formation in the western area.

The small form of *T. dominicense dominicense* in the La Boca formation, the typical form of the nominate subspecies in the middle part of the Gatun formation, and *T. dominicense hadratatum* in the upper part of the Gatun in the western area constitute a lineage graded in increasing size and increasing number of ribs with decreasing age. This lineage left no descendants in American waters.

Occurrence: Upper part of Gatun formation, western area (middle Miocene), localities 182, 182a, 185.

Trachycardium (Dallocardia) baiterum Woodring, n. sp.

Plate 116, figures 15, 16

Small, height greater than length, slightly inequilateral, strongly convex. Umbo high, moderately wide. Lunule narrow, smooth. Sculpture of 30 to 35 (generally 30) ribs, separated by narrow groove. Crest of ribs generally slightly inverted V-shaped; exceptionally flat. Seven to 10 posterior ribs divided, or none divided. Median ribs faintly to distinctly divided, or not divided. Widely spaced prickles preserved on seven anterior ribs on largest valve (locality 138c). Anterior lateral teeth closer to cardinal teeth than posterior lateral teeth.

Length 27.2 mm, height 28.6 mm, convexity 13.5 mm (type). Length 29 mm, height 32.7 mm, convexity 13.4 mm (largest specimen).

Type (left valve): USNM 647474; paratype (right valve), USNM 647475.

Type and paratype locality: 139c (USGS 22018, East side of road to refinery on Payardi Island, about 100 m southwest of refinery gate, Panamá), middle part of Gatun formation.

This small variable species is especially characteristic of the lower part of the Gatun formation and of strata near the base of the middle part: a total of about 100 specimens, ranging in length from

2.5 to 29 mm. The posterior ribs of valves from the same locality are undivided, as on the type, or are divided, as on the paratype.

Trachycardium puebloense (Anderson, 1929, p. 164, pl. 19, figs. 1, 2; middle Miocene, Colombia) is larger (length 40 mm), and its interribs are not as narrow as those of *T. baiterum.*

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, localities 138, 138a, 138c, 138d, 138h. Middle part, eastern area, localities 139b, 139c, 139e, 139f, 139g, 140, 146. Middle Miocene deposits, Darién Province, Panamá (USGS 8477).

Subgenus Phlogocardia Stewart

Stewart, Acad. Nat. Sci. Philadelphia Spec. Pub. 3, p. 263, 1930.

Type (orthotype): *Cardium belcheri* Broderip and Sowerby, living, Gulf of California to Ecuador.

Phlogocardia is a paciphile subgenus. It appeared in the Caribbean region in middle Miocene time and during early Miocene time in western Florida (*Trachycardium cestum* (Dall); Chipola formation), but in Pacific waters, it is unknown before the Pliocene.

Trachycardium (Phlogocardia) stiriatum (Brown and Pilsbry)

Plate 116, figure 25

Cardium (Trachycardium) stiriatum Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 63, p. 366, pl. 28, fig. 11, 1911 (Miocene, Canal Zone).

Cardium stiriatum Brown and Pilsbry, Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 225 (assigned to subgenus *Trachycardium*), pl. 27, figs. 4, 5, 1922 (Miocene, Costa Rica, Panamá).

Cardium spec. (vielleicht eine neue Art), Toula, K. k. Geol. Reichsanstalt Jahrb., v. 58, p. 721, pl. 27, fig. 5, pl. 28, figs., 15a, 15b, 1909 (Miocene, Canal Zone).

Of medium size, height greater than length, slightly inequilateral, strongly convex. Umbo narrow. Lunule moderately narrow, smooth. Sculpture of 26 to 32 (generally 28 to 32) ribs; interribs very narrow. Anterior ribs bearing coarse tubercules, gradually shifted adposteriorly to posterior side of rib and becoming drop shaped and oblique. Anterior part of median ribs bearing one or two obscure threads, posterior edge bearing vertically undulated and twisted narrow crest. Posterior ribs bearing drop-shaped oblique tubercules. Crest invariably worn off on some median ribs; such ribs appear to be divided or show linear radial markings. Anterior lateral teeth closer to cardinal teeth than posterior lateral teeth.

Length 32.2 mm, height 43.5 mm, convexity 16.2 mm (figured left valve). Length 35.5 mm, height 44 mm, convexity 21 mm (largest specimen).

Type: Lectotype, herewith designated, right valve figured by Brown and Pilsbry, Acad. Nat. Sci. Philadelphia 1755.

Type locality: Gatun Locks excavation, Canal Zone, Gatun formation.

Trachycardium stiriatum is fairly common in the middle part of the Gatun formation and rare in the upper part in the eastern area: a total of 54 specimens, eight of which are articulated. They range in length from 13.5 to 35.5 mm. The crest on median ribs of most of the specimens from the Bocas del Toro area is better preserved than on those from the Gatun.

As recognized by Brown and Pilsbry, this species is closely related to *T. belcheri*, the type species of *Phlogocardia*. It is, however, smaller than the living species and has a few more ribs. The undulations on the crest of median ribs are coarser on the Gatun species than on *T. lingualeonis* (Guppy) (Woodring, 1925, p. 136, pl. 18, figs. 12, 13), which occurs in the Bowden formation of Jamaica and the Gurabo formation of the Dominican Republic.

The type of *T. durum*, collected at the spillway of Gatun Dam, probably is a poorly preserved specimen of *T. stiriatum.*

A species of *Phlogocardia* from deposits of late Miocene age in western Florida was described as *T. stiriatum leonense* (Mansfield, 1932b, p. 110, pl. 22, figs. 1, 9). It is considerably larger than *T. stiriatum* (length 49.3 mm), and the anterior edge of median ribs bears a very narrow sharp thread. Specific rank for the Florida form is justified.

Occurrence: Middle and upper parts of Gatun formation (middle Miocene). Middle part, eastern area, localities 146, 147a, 147b, 147h, 151, 155, 155a, 155b, 156, 157, 159, 159b; western area, locality 160. Upper part, eastern area, localities, 173, 177 (iden tification doubtful), 178. Deposits of middle Miocene age, Limón Province, Costa Rica. Limónes formation (late Miocene), Bocas del Toro area, Panamá.

Subgenus Mexicardia Stewart

Stewart, Acad. Nat. Sci. Philadelphia Spec. Pub. 3, p. 263, 1930.

Type (orthotype): *Cardium procerum* Sowerby, living, Gulf of California to Perú.

Mexicardia is another paciphile subgenus. In the western Atlantic part of the Miocene Caribbean province, it has been found in formations of middle

Miocene age in Costa Rica, Panamá, and the Dominican Republic. Like *Phlogocardia*, it is unknown in Pacific waters before the Pliocene.

Trachycardium (Mexicardia) dominicanum costaricanum (Olsson)

Plate 116, figures 29, 30

Cardium costaricanum Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 226 (assigned to subgenus *Trachycardium*), pl. 27, fig. 3, 1922 (Miocene, Costa Rica).

Cardium (Trachycardium) dominicanum Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 5, p. 1082, 1900 (Miocene, Canal Zone); not pt. 6, pl. 48, fig. 16, 1903 (Miocene, Dominican Republic). Pilsbry and Brown, Acad. Nat. Sci. Philadelphia Proc., v. 63, p. 367, 1911 (Miocene, Canal Zone; Dall's record).

Small, narrow, height greater than length, slightly inequilateral, strongly convex. Umbo full and wide. Lunule not differentiated. Sculpture of 22 to 24 (generally 22) ribs, about twice as wide as deeply grooved interribs. Crest of anterior and median ribs rounded; posterior ribs flattened, except anterior edge. Anterior ribs more or less distinctly noded, nodes generally stronger on slightly raised posterior part of ribs, or anterior ribs smooth. Lateral teeth almost equally distant from cardinal teeth.

Length 21.5 mm, height 28.7 mm, convexity 6.4 mm (larger illustrated specimen). Length 17.3 mm, height 31.1 mm, convexity 6.5 mm (largest specimen).

Type: Paleontological Research Inst. 21254.

Type locality: East Grape Point Creek, Limón Province, Costa Rica, deposits of middle Miocene age.

Though *Trachycardium dominicanum costaricanum* is diminutive compared with the very large type species of *Mexicardia* (length as much as 95 mm), it is similar to very immature specimens of the type species. It is, however, narrower and more convex than immature specimens of the type species and the nodes on noded anterior ribs are coarser.

The nominate subspecies of *T. dominicanum*, which is abundant in the Cercado formation of the Dominican Republic at USGS locality 8525 on Río Mao (Maury's Bluff 3), is somewhat larger than *T. dominicanum costaricanum* (length 25.3 mm), and more of its ribs are noded, up to all of the anterior and median ribs, except in the umbonal area. The type lot of two valves (USNM 157524) of the nominate subspecies was forwarded to Dall by Gabb. The type locality therefore is not more definite than the Dominican Republic. The left valve illustrated by Dall is herewith designated the lectotype.

T. dominicanum costaricanum occurs in the lower and middle parts of the Gatun formation, but only 15 specimens were collected.

Occurrence: Lower and middle Miocene parts of Gatun formation (middle Miocene). Lower part, localities 136, 136a, 137, 137a. Middle part, eastern area, localities 155, 155a. Deposits of middle Miocene age, Limón Province, Costa Rica.

Subfamily FRAGINAE

Genus Chrysocardium Woodring, n. gen.

Type: *Chrysocardium aurum* Woodring, n. sp., Eocene, Canal Zone.

Small, somewhat *Fragum*-like in outline, height greater than length, decidely inequilateral, strongly convex. Wide median depression extending from umbo to ventral margin. Umbo narrow, high. Lunule not differentiated. Sculpture of 25 strong ribs. Hinge massive for size of shell. Left anterior cardinal tooth narrow, posterior cardinal tooth triangular. Left posterior lateral teeth adjoining cardinal socket, anterior lateral teeth close to anterior cardinal tooth. Posterior adductor scar buttressed on anterior side, anterior adductor scar obscure.

However unfortunate it may be to base a genus on a single valve, this distinctive Eocene cardiid is named. It may be derived from an unknown Late Cretaceous genus. In any event, no Paleocene or Eocene genus that has come to my attention is similar to it.

Chrysocardium aurum Woodring, n. sp.

Plate 86, figures 1, 2

Features of the genus, which is monotypic.

Details of outline and ribbing.—Anterior dorsal margin almost straight, anterior lateral margin concave. Dorsal part of posterior margin barely concave, upper part of lateral margin almost straight, lower part convexly curving to ventral margin. Ventral margin concave at depression. Eight anterior ribs, 6 median, and 11 posterior. Third, fourth, and eighth (from margin) anterior ribs wider than others; interribs moderately narrow. Median rib bordering depression on both sides wider and higher than others; faint or distinct groove on some ribs; interribs narrow to moderately narrow. Posterior ribs, as usual, decreasing in width near margin; interribs very narrow, wider near margin.

Length 18.5 mm, height 21.8 mm, convexity 8 mm (type).

Type (left valve): USNM 647478.

Type locality: 38 (USGS 17166, Quebrada de Oro, Río Casaya area, 2.1 miles (3.4 km) southeast of east end of Gamboa bridge, Canal Zone), middle Eocene part of Gatuncillo formation.

The single valve is a silicified fossil.

Occurrence: Gatuncillo formation (middle Eocene part), locality 38.

Genus Americardia Stewart

Stewart, Acad. Nat. Sci. Philadelphia Spec. Pub. 3, p. 267, 1930.

Type (orthotype): *Cardium medium* Linné, living, North Carolina to northern Brasil.

Though *Americardia* is generally assigned subgeneric rank under *Trigoniocardia*, as was done by Stewart, treatment of both as genera is justified, as was done by Abbott (1958, p. 125–126).

Americardia cf. A. media (Linne)

Small, posterior angulation subdued. Sculpture of narrow, flat-topped ribs, slightly wider than interribs: 8 on posterior slope, about 30 on remainder of shell. Ventral part of ribs obscurely noded. Hinge inaccessible.

Length 17.3 mm, height (possibly not quite complete) 17.5 mm, convexity about 8.5 mm.

A small incomplete right valve from the La Boca formation is the earliest representative of *Americardia* in the Tertiary Caribbean province so far recorded. The posterior angulation is more subdued than that of immature valves of *A. media*, which extends back to the middle Miocene; the rib count is a few less, and the interribs are wider. *A. burnsii* (Dall, 1890–1903, p. 1101, 1900; pl. 48, fig. 15, 1903; Chipola formation, Florida) is still smaller (maximum estimated length 11 mm), and its posterior angulation is strong.

Occurrence: La Boca formation (early Miocene), Gaillard Cut area, locality 116a.

Genus Trigoniocardia Dall

Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 5, p. 1075, 1900.

Type (orthotype): *Cardium graniferum* Sowerby, living Gulf of California to northern Perú.

Thirty-two names have been proposed or used for species and subspecies of this endemic American genus in the Tertiary Caribbean province. They range in age from late Oligocene to late Pliocene. Nine of them, however, are regarded as synonyms. The remainder may be divided into five groups: the subgenus *Trigoniocardia* s.s.; the subgenus *Apiocardia*, including the group of *T. obovalis*, the group of *T. haitensis*, and the group of *T. antillarum*; and the subgenus *Goniacardia*.

Subgenus Trigoniocardia s.s

The type species of *Trigoniocardia* is small, widely ovate, and the posterior slope is so narrow that it barely affects the outline. The ribs on the central part of the shell are few and the interribs very wide. Its anterior lateral teeth are crowded against the anterior cardinal tooth or are farther removed, but still much closer than the posterior lateral teeth. This subgenus may be monotypic.

Trigoniocardia (Trigoniocardia?) minutissima (Toula)

Cardium minutissimum Toula, K. k. Geol. Reichsanstalt Jahrb., v. 61, p. 494, pl. 31, figs. 4a, 4b, 1911 (Miocene, Canal Zone).

Toula named, appropriately enough, as *Cardium minutissimum* a minute right valve (length and height 0.7 mm) from the middle part of the Gatun formation. According to his illustrations, it is subcircular and sculptured with 13, possibly 14, ribs, which are widely spaced, except at the ends of the shell. The smallest available valve of *Trigoniocardia granifera* has a length of 4.5 mm. It is not quite subcircular, and the interribs on the central part of the shell are narrower than shown on Toula's exterior drawing.

Toula's species is to be treated as a *nomen dubium* until it can be correlated with a cardiid at a later growth stage. It would have been better had such a very immature specimen been left unnamed.

Occurrence: Middle part of Gatun formation (middle Miocene), eastern area, Toula's record.

Subgenus Apiocardia Olsson

Olsson, Mollusks of the tropical eastern Pacific; Panamic-Pacific Pelecypoda, p. 252, Paleontological Research Inst., 1961.

Type (orthotype): *Cardium obovale* Sowerby, living, Gulf of California to northern Perú.

Group of Trigoniocardia obovalis

The species of the group of *Trigoniocardia obovalis* are small to large. They are more or less narrow and oblique, and generally are angulated at the posterior slope. The posterior slope is wide. The interribs generally are of moderate width, exceptionally narrow. The anterior lateral teeth are crowded against the anterior cardinal tooth in all species of *Apiocardia*, the hinge of which is known.

In all fossil specimens of *Trigoniocardia*, the presence or absence of tubercles on the ribs may bear no relation to their original presence or absence. Moreover, as pointed out by Gardner (1926–47, p. 141, 142, 1926), when any of them are lost, no trace of a scar is left.

Trigoniocardia (Apiocardia) cf. T. (A.) simrothi (Dall)

Plate 98, figure 5

Small, moderately narrow, angulated at posterior slope. Posterior slope wide, slightly concave. Sculpture of 12 ribs in front of angulation (anterior 2 missing on figured valve), bearing low tubercles, except in umbonal area, or tubercles absent. Seven narrow ribs on posterior slope. Interribs moderately narrow, narrower than ribs; concentric threads in interribs obscure. Hinge inaccessible.

Length (incomplete) 10.7 mm (estimated restored length 12 mm), height 13 mm (figured left valve).

Thirty-two valves of this small *Trigoniocardia* are in collections from the La Boca formation. That illustrated is the only one that shows tubercles. Though these fossils are not in good condition, they are closely related to *T. simrothi* (Dall, 1890–1903, pt. 5, p. 1104, 1900; pt. 6, pl. 48, fig. 8, 1903; Chipola formation, Florida) and the presumably synonymous *T. apatetica* (Dall, 1890–1903, pt. 5, p. 1105, 1900; pt. 6, pl. 48, fig. 6, 1903; Oak Grove sand member of Shoal River formation, Florida).

Two internal molds from the lower member of the Alhajuela formation, slightly larger than the valves from the La Boca, are doubtfully identified as this species.

Occurrence: La Boca formation (early Miocene), Gaillard Cut area, localities 99b, 99c, 99d, 99h, 100b, 114, 115. Lower member of Alhajuela formation (early Miocene), locality 79 (identification doubtful).

Trigoniocardia (Apiocardia) aminensis (Dall)

Plate 14, figures 3–5, 8, 9

Cardium (*Trigoniocardia*) *aminense* Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 5, p. 1104, 1900; pt. 6, pl. 48, fig. 11, 1903 (Miocene, Dominican Republic). Maury, Bull. Am. Paleontology, v. 5, no. 29, p. 212, 1917 (Miocene, Dominican Republic; Dall's record).

Of medium size to moderately large. Narrow, oblique, and angulated at posterior slope, or in lower part of Gatun formation showing that outline and also wider, less oblique, and subdued angulation outline. Posterior slope wide, flattened on angulated valves, slightly bulging on valves that have subdued angulation. Sculpture of 17 to 25 ribs: 10 to 16 (generally 11 to 13) in front of angulation, 6 to 10 (generally 8) on posterior slope. Ribs bearing tubercles on all ribs, on parts of some, especially on rib at angulation, or exceptionally on none. Interribs in front of angulation about half as wide as ribs; exceptionally very narrow on anterior part of that area. Concentric threads in interribs generally strong. Anterior lateral teeth crowded against anterior cardinal tooth.

Length 13.5 mm, height 19.5 mm, convexity 9 mm (figured right valve from middle part of Gatun formation, largest specimen). Length 10.7 mm, height 14.2 mm, convexity 6.4 mm (type).

Type (left valve): USNM 113800.

Type locality: Potrero, Río Amina, Dominican Republic, presumably Gurabo formation.

Trigoniocardia aminensis occurs throughout the Gatun formation (but only three minute valves in the upper part in the eastern area) and also in the Toro limestone member of the Chagres sandstone. It is widespread and locally extraordinarily abundant in the lower part of the Gatun, and widespread, but not abundant, in the middle part. An estimated 700 are available from the lower part, including an estimated 600 in two collections from the same locality near Cativa (138c and 138d). Minute valves, less than 2.5 mm long are not unusual. the smallest of all having a length of 1 mm. Thirteen of 17 lots from the middle part consist only of immature valves.

The relatively wide form that has subdued angulation (pl. 114, fig. 3) is the prevalent form in the lower part of the Gatun, but it is associated with the narrow form (pl. 114, fig. 5), whereas all except one of about 100 from the middle part represent the narrow form (pl. 114, fig. 9).

The type of *T. aminensis* (pl. 114, fig. 8) is narrow and so are 10 others from the Dominican Republic, all from the Gurabo formation, including two topotypes. The ribs of the type are higher than those of the others from the Dominican Republic and also than those from Panamá,and slightly overhanging, and the interribs in front of the angulation on the type are slightly wider.

The species from the La Boca formation identified as *T.* cf. *T. simrothi,* is smaller and, though angulated, is wider than the angulated form of *T. aminensis. T. heridia* (Olsson, 1922, p. 227, pl. 27, fig. 10; middle Miocene, Costa Rica) also is smaller and wider.

Occurrence: Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, localities 136, 137, 137a, 138, 138c, 138d, 138e, 138f, 138g. Middle part, eastern area, localities 139b, 139c, 139e, 139g, 140, 145, 146, 147, 147b, 147c, 147d, 147h, 152, 159; western area, localities 161c, 161d, 166, 169, 170, 170a. Upper part, eastern area, locality 163; western area, locality 185. Toro limestone member of Chagres sandstone (late Miocene or early Pleocene), locality 196. Gurabo formation (middle Miocene), Dominican Republic.

Groups of Trigoniocardia haitensis and T. antillarum

The group of *Trigoniocardia haitensis* (Sowerby) (Pflug, 1961, p. 80, pl. 24, figs. 10, 11; Miocene, Dominican Republic) is characterized by an ovate-subquadrate outline and generally subdued angulation. The posterior slope is wide and slightly concave to slightly bulging. The interribs generally are of moderate width, exceptionally narrow. No sharp demarcation is apparent between this group and the preceding group. Some species are intermediate, and others, such as *T. aminensis*, show features of both groups.

The group of *T. antillarum* (d'Orbigny) (Weisbord, 1964, p. 256, pl. 35, figs. 10–12, pl. 36, figs. 2–6, as *T. caboblanquensis*), a living Caribbean species, is a minor group distinguished from the group of *T. haitensis* by the small size of the species. Neither group is represented in the faunas under study.

Subgenus Goniacardia Woodring, n. subgen.

Type: *Cardium (Fragum) callopleurum* Gabb, late Pliocene, Costa Rica.

Small or of medium size, ovate-subquadrate. Angulation subdued at mature stage on species of medium size. Ribs inverted V-shaped, except at ends of valve. Spacing of ribs on main part of valve moderate or wide. Anterior lateral teeth crowded against anterior cardinal tooth.

Goniacardia embraces two distinctive species: the type species (Gabb, 1881b, p. 375, pl. 47, fig. 77), from the late Pliocene Moín formation, and a smaller species, *Trigoniocardia melajoensis* (Jung, 1969, p. 366, pl. 25, figs. 11, 12), which occurs in the late Miocene Melajo clay member of the Springvale formation of Trinidad (type locality) and also in the Savaneta glauconitic sandstone member of the Springvale, of the same age.

Subfamily PROTOCARDIINAE

Genus Nemocardium Meek

Meek, A report on the invertebrate Cretaceous and Tertiary fossils of the upper Missouri country: U. S. Geol. Survey of the Territories (Hayden), Rept. 9, p. 167, 1876.

Type (monotype): *Cardium semiasperum* Deshayes, Eocene, Paris basin.

Cardium (*Protocardia*) *newberryanum* (Gabb, 1881a, p. 344, pl. 44, fig. 17) was alleged by Gabb to have been collected by Newberry at Gatun. It is an internal mold of articulated valves of a large species (length 43 mm, height 38 mm), doubtless a *Protocardia* from an unknown Upper Cretaceous locality.

Nemocardium hadraterum Woodring, n. sp.

Plate 99, figures 7, 11

Small to large, broadly ovate, height generally slightly less than length, umbo high and strongly inflated. Posterior end slightly more extended than anterior. (Extreme posterior end of type missing.) Posterior ribs wider and more widely spaced than those on remainder of valve and standing out more in relief. Hinge inaccessible.

Length (almost complete) 38.8 mm, height 35.8 mm, convexity about 10 mm (type, largest specimen).

Type (right valve): USNM 647485; paratype (internal mold of articulated valves) USNM 647487.

Type locality: 119b, (USGS 6669, Panama Canal, west side of Las Cascadas Reach, upper bed of limestone near Tower N, Canal Zone), La Boca formation; paratype locality: 101h (USGS 23652, Panama Canal, west side of Las Cascadas Reach, Canal stations 1774 to 1778 plus 23 m, near top of Canal cliff, Canal Zone), La Boca formation.

Though *Nemocardium hadraterum* is represented by 40 specimens from the La Boca formation, all except two are internal molds, for the most part molds of articulated valves. These molds show no trace of ribs, except more or less distinct posterior ribs, or, as on the type (pl. 99, fig. 7), a few posterior ribs, or even none. The paratype (pl. 99, fig. 11), an internal mold of articulated valves, shows distinct posterior ribs. Both sets of ribs are visible on a corroded impression of an incomplete left valve (locality 125).

Two forms are represented by specimens from the La Boca: a large form, such as the type, and a small form. Twenty-three of the small form, one of which, the paratype, is illustrated (pl. 99, fig. 11), but none of the large, were collected at locality 101h. All are internal molds and all except six are molds of articulated valves. Only the small form was collected at three other localities.

The outline of *N. hadraterum* is much like that of *N. nicolletti* (Conrad) (Harris, *in* Harris and Palmer, 1946–47, p. 92, pl. 20, figs. 16–19, 1946; late Eocene, Louisiana and Mississippi). The species from the La Boca is smaller, the ratio of height to length is higher, and the posterior end is less truncated or not truncated.

Mansfield's (1937, p. 258) *Protocardia* sp. from the late Oligocene Suwannee limestone and early Miocene Tampa limestone, both of Florida, and a small silicified valve from the Tampa at Ballast Point, collected later by C. R. Locklin, represent *Nemocardium*.

The species from the La Boca and that from the Tampa, which are considered to be of the same age, are the last known American representatives of an essentially Cretaceous and early Tertiary genus that survives until the present time in Japanese waters.

Occurrence: La Boca formation (early Miocene), Gaillard Cut area, localities 99d, 99e, 99f, 99h, 101h, 102a, 119b, 119c, 120, 125; Las Cruces area, locality 94.

Genus Microcardium Thiele

Thiele, Handbuch der systematischen Weichtierkunde, pt. 3, p. 878, Jena, 1934.

Type (logotype, Keen, Mus. Royal Histoire Nat. Belgique Bull., v. 13, no. 7, p. 14, 1937): *Cardium* (*Fulvia*) *peramabilis* [*peramabile*] Dall, living, Rhode Island to Gulf of Mexico and Barbados.

The type species has a considerable recorded depth range: 17 to 350 fathoms.

Microcardium microtatum Woodring, n. sp.

Plate 90, figure 18

Very small, ovate, height slightly less than length or equal to length, umbo high and strongly inflated. Ribs and interribs on about posterior third of valve slightly wider than on anterior two-thirds. No concentric sculpture on uncorroded valves, many of which are well preserved, but corroded valves reveal inner shell layer bearing concentric threads, more widely spaced than ribs, forming low nodes on ribs. Faint nodes, presumably representing base of minute prickles, on parts of some posterior ribs on uncorroded valves. Hinge inaccessible.

Length 7.6 mm, height 7.6 mm, convexity about 3.5 mm (type, largest specimen).

Type (right valve): USNM 647503.

Type locality: 41b (USGS 18839, East side of Palenquilla Point, cove north of triangulation station and southwest of Corozo Island, Canal Zone), marine rocks of late Eocene age.

Microcardium microtatum, based on 37 specimens from the marine rocks of late Eocene age, is by far the earliest and also the smaliest species of the genus. Heretofore, the earliest were in the middle Mioceen of Costa Rica, Jamaica, the Dominican Republic, and Trinidad, ranging in length from about 10 to 23 mm. Though the length of the only complete specimen of *M. jamaicense* (Dall) (Woodring, 1925, p. 147, pl. 19, fig. 17; Bowden formation, Jamaica) is 6.2 mm, a fragment suggests a length of at least 10 mm. The length range in the sample from the Canal Zone is 2.7 to 7.6 mm.

The absence of exterior concentric sculpture indicates that *M. microtatum* is a connecting link between *Nemocardium* s.s. and typical *Microcardium*.

Occurrence: marine rocks of late Eocene age, localities 40d, 41b.

Microcardium pollostum Woodring, n. sp.

Plate 92, figures 9, 12

Small, ovate, height very slightly less than length, umbo high and strongly inflated. Ribs and interribs on about posterior half of valve barely wider than on anterior half, or not wider. Faint concentric threads on ventral part of type, forming minute nodes on ribs; neither discernible on paratype and other specimens. Hinge inaccessible.

Length 8.5 mm, height 8.4 mm, convexity about 2.5 mm (type). Length 10.3 mm, height 10 mm, convexity about 2.5 mm (largest specimen).

Type (left valve): USNM 647504; paratype (left valve): USNM 647505.

Type and paratype locality: 54k (USGS 18834, Southwestern part of Barro Colorado Island, stream crossing Conrad Trail at Conrad 2, about 60 m upstream from mouth, Canal Zone), Caimito formation.

The moderately deep-water facies of the Caimito formation on Barro Colorado Island yielded five valves of this small *Microcardium*. On all valves, the thin aragonitic shell is recrystallized to calcite. A discontinuity between posterior and anterior ribs, like that on the middle Miocene and later species, is not apparent even on valves that show barely wider posterior ribs.

The presence of concentric sculpture, at least on the type, indicates that *M. pollostum* is intermediate between *M. microtatum* and the middle Miocene and later species.

Occurrence: Caimito formation (late Oligocene), localities 54j, 54k.

Genus Lophocardium Fischer

Fischer, Manuel de Conchyliologie, p. 1087, 1887.

Type (monotype): *Cardium Cumingi* [*cumingii*] Broderip, living, Acapulco, México to Colombia.

This paciphile genus is rare as a fossil in the present Caribbean region. It occurs in the late Eocene of Colombia, the middle Miocene of Costa Rica, Panamá, and the Dominican Republic, and the late Miocene of Panamá.

Lophocardium gurabicum (Maury)

Plate 114, figures 1, 2 6

Protocardia gurabica Maury, Bull. Am. Paleontology, v. 5, no. 29, p. 213, pl. 36, fig. 10, 1917 (Miocene, Dominican Republic). Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 229 (assigned to subgenus *Lophocardium*), pl. 27, figs. 7–9, 1922 (Miocene, Costa Rica, Panamá).

Not *Lophocardium gurabicum* (Maury), Olsson, Neogene mollusks from northwestern Ecuador, p. 58, pl. 6, fig. 3, Paleontological Research Inst., 1964 (Miocene, Ecuador).

Protocardia (*Lophocardium*) *gurabica vaughaniana* Mansfield, Florida Geol. Survey Bull. 8, p. 115, pl. 24, fig. 2, 1932 (Miocene, Florida).

Thracia?, n. sp., Toula, K. k. Geol. Reichsanstalt Jahrb., v. 58, p. 733, pl. 28, fig. 8, 1909 (Miocene, Canal Zone).

Large, broadly ovate, height less than length, inequilateral, posterior end more extended than anterior, and valves gaping. Umbo high and strongly inflated. Lunule narrow, inflated. Sculpture finely reticulate, ribs slightly stronger and slightly more widely spaced than concentric threads. Sculpture of posterior slope like that of remainder of valve and slope not set off by thin radial lamella. Left anterior cardinal tooth strong; posterior cardinal tooth minute. Left posterior lateral tooth suppressed as compared with anterior lateral tooth. Right hinge unknown.

Length (almost complete) 39.7 mm, height 36.1 mm, convexity about 15 mm (figured right valve). Length (incomplete) 42 mm (estimated restored length 46 mm), height 36 mm, convexity about 15 mm (largest specimen).

Type: Paleontological Research Inst.

Type locality: Río Gurabo at Los Quemados, Dominican Republic, Gurabo formation.

Though seven specimens of *Lophocardium gurabicum* were found in the middle part of the Gatun formation, an immature left valve (pl. 114, figs. 2, 6) is the only preserved shell. The others are internal molds, two of them molds of articulated valves. The molds show more or less of the fine sculpture, especially that illustrated on plate 114, figure 1. An incomplete right-valve mold from the upper part of the Gatun has some shell material attached to it. Olsson's (1922) figure 7 represents a left valve from the Gatun.

L. gurabicum is distinguished from the two surviving species in the eastern Pacific Ocean by the absence of a thin radial lamella setting off the posterior slope and by the presence, at least on the left valve, of a weak posterior lateral tooth and a strong anterior lateral tooth. The hinge of no other fossil specimen is known. So far as sculpture is concerned, the species from the Gatun is similar to the small late Eocene species from Colombia recorded by Clark (*in* Clark and Durham, 1946, p. 63, pl. 5, figs. 7; 9) as *Nemocardium* (*Lophocardium*) cf. *N. gurabicum*. The largest specimen of the Columbian species in USNM collections has a length of 21.5 mm.

Recognition of *L. gurabica vaughaniana* is hardly justified. The small sample of six specimens of *L. gurabica* from locality 160 shows a considerable range of variation in outline.

Occurrence: middle and upper parts of Gatun formation (middle Miocene). Middle part eastern area, locality 155b; western area, locality 160. Upper part, eastern area, locality 172. Gurabo formation (middle Miocene), Dominican Republic. Middle Miocene deposits, Limón Province, Costa Rica (Olsson's record). Limónes formation (late Miocene), Limón Province, Costa Rica (Olsson's record). Deposits of late Miocene age, western Florida.

Subfamily LAEVICARDIINAE

Genus Dinocardium Dall

Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 5, p. 1074, 1910.

Type (orthotype): *Cardium magnum* Born = *Cardium ventricosum* Bruguière, = *Cardium robustum* [Lightfoot], living, New Jersey to Belize.

By the time Dall described the type species on page 1099 of the publication just cited, he realized that its proper name is *Cardium robustum.*

Dinocardium robustum [Lightfoot], small form

Plate 107, figures 2, 4

Cardium robustum [Lightfoot], Catalogue of the Portland Museum, p. 58, 1786 (living, Florida).

Cardium (*Cerastoderma*) *robustum* Solander, Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 5, p. 1099 (assigned to section *Dinocardium*), 1910 (Pliocene to Holocene, southeastern United States).

Dinocardium robustum Solander, Clench and L. C. Smith, Johnsonia, no. 13, p. 9, pl. 6, 1944 (living, New Jersey to Belize).

Cardium (*Dinocardium*) *robustum* Solander, Olsson and Harbison, Acad. Nat. Sci. Philadelphia Mon. 8, p. 102, 1953 (Pliocene, Florida).

Large, obliquely ovate, height less than length, strongly convex, inequilateral, posterior end more extended than anterior. Umbo high and strongly inflated. Sculpture of 31 to 35 narrow ribs, generally wider than interribs. Ribs flattened on posterior slope. Faint remnants of nodes on some anterior ribs of some specimens. Hinge unknown.

Length 75.5 mm, height 65.5 mm, convexity (both valves) 47.5 mm (larger figured specimen, largest complete specimen).

This big cardiid, as well as the big scallop *Flabellipecten gatunensis,* is conspicuous in the upper member of the Alhajuela formation. On several occasions, Olsson called attention to the cardiid (Olsson, 1932, p. 98; 1942a, p. 243; 1964, p. 55); in fact, he collected one of the lots in 1919 (locality 85a).

Some 60 specimens are available. All, including 12 molds of articulated valves, are internal molds that show the ribbing more or less satisfactorily. This kind of preservation, however, does not reveal the narrow transverse nodes on the anterior ribs of living shells. The range in length is a little more than 4.5 to a little more than 75.5 mm.

This is the first fossil record for *Dinocardium robustum* in the present Caribbean region. The fossils are regarded as a relatively small late early Miocene form. A length of 12 cm is not unusual among living specimens, and Pliocene fossils reach a length of 10 or 11 cm. A subspecific name would be appropriate, if the preservation were better *Dinocardium brantlyi* (Weisbord, 1929, p. 19, pl. 4, fig. 7), from an unspecified part of the Miocene in Colombia, has more ribs and its anterior end is more extended than the posterior.

Why this species is abundant in the upper member of the Alhajuela formation and why it is found only in that unit among the faunas under consideration are unknown.

Occurrence: Upper member of Alhajuela formation (early Miocene), localities 85, 85a, 86, 87, 88, 89, 90a, 92. Caloosahatchee formation (Pliocene), Florida. Living, New Jersey to Belize.

Dinocardium cf. D. cabezai (Gardner)

Plate 116, figure 26

Of medium size, broadly ovate, height equal to length or very slightly less than length, strongly convex, inequilateral, posterior end more extended than anterior. Umbo high and strongly inflated. Sculpture of 30 or 31 narrow ribs, not including few weak ribs on posterior slope. Ribs about twice as wide as interribs; those on ventral median part of valve divided. Hinge unknown.

Length (almost complete) 41.5 mm, height 41.5 mm, convexity about 19.5 mm (figured right valve).

Dinocardium cf. *D. cabezai* is represented by a right and a left valve, both corroded. They were collected in the middle part of the Gatun formation at locality 160. As they have practically the same dimensions, they probably were originally paired.

This species is the first Caribbean representative of a group of species found in the Alum Bluff group of Florida. Of those species, that from the Gatun is most similar to *D. cabezai* (Gardner, 1945, p. 102, pl. 4, figs. 7, 8, 10; syntypes from Shoal River formation, Florida). The species from the Gatun has a higher and more inflated umbo, and wider ribs. The ribs on the posterior slope of these species are weak. For such species, Olsson proposed the subgeneric name *Exocardium* (Olsson, 1964, p. 55; type (orthotype): *Cardium* (*Dinocardium*) *ecuadorialis* [*ecuadoriale*] Olsson, middle Miocene, Ecuador, Perú). Gradations, however, are apparent from the flattened ribs of *D. robustum* to weak ribs to very weak ribs that disappear adventrally.

Occurrence: Middle part of Gatun formation (middle Miocene), western area, locality 160.

Genus Laevicardium Swainson

Swainson, A treatise on malacology, p. 373, London, 1840.

Type (logotype, Stoliczka, India Geol. Survey Mem., Palaeontologia Indica, Cretaceous fauna of southern India, v. 3, p. XVIII, 1871): *Cardium oblongum* Gmelin, living, western Pacific Ocean.

Laevicardium laevigatum (Linne)

Plate 116, figures 9, 17

Cardium laevigatum Linné, Systema naturae, 10th ed., p. 680, 1758 (living, locality unknown).

Laevicardium laevigatum (Linné), Clench and L. C. Smith, Johnsonia, no. 13, p. 22, pl. 12, figs. 1–5, 1944 (living, North Carolina to Paraná, Brasil).

Laevicardium cf. *L. laevigatum* (Linné), Jung, Bull. Am. Paleontology, v. 55, no. 247, p. 370, 1969 (Pliocene, Trinidad).

Cardium (*Laevicardium*) *serratum* Linné, Gabb, Acad. Nat. Sci. Philadelphia Jour., 2d ser., v. 8, p. 374, 1881 (Pliocene, Costa Rica). Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 5, 1110, 1900 (Miocene to Holocene, Caribbean region and southeastern United States). Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 63, p. 367, 1911 (Miocene, Canal Zone). Maury, Bull, Am. Paleontology, v. 5, no. 29, p. 212, pl. 36, fig. 8, 1917 (Miocene, Dominican Republic). Maury, New York Acad. Sci. Scientific Survey of Porto Rico and Virgin Islands, v. 3, pt. 1, p. 36, 1920 (Miocene, Puerto Rico). Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 73, p. 421, 1922 (Miocene, Dominican Republic). Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 228, pl. 27, figs. 11, 12, 1922 (Miocene, Costa Rica, Canal Zone). Maury, Bull. Am. Paleontology, v. 10, no. 42, p. 138, pl. 23, fig. 14, 1925 (Miocene, Trinidad). Maury, Brasil Serv. Geol. e Mineral., Mon. 4, p. 313, pl. 17, fig. 14, 1925 (Miocene, Brasil). Woodring, Carnegie Inst. Washington Pub. 366, p. 145, pl. 19, figs. 14–16, 1925 (Miocene, Jamaica). Weisbord, Bull. Am. Paleontology, v. 14, no. 54, p. 20, pl. 4, fig. 6, 1929 (Miocene, Colombia). Anderson, California Acad. Sci. Proc., 4th ser., v. 18, no. 4, p. 165, 1929 (Miocene, Colombia).

Cardium serratum Linné and *Cardium serratum sybariticum* Dall, Guppy and Dall, U. S. Nat'l. Mus. Proc., v. 19, p. 327, 1896 (Miocene, Jamaica).

Laevicardium serratum (Linné), Böse, Inst. Geol. México Bol. 22, p. 80, 1906 (Pliocene(?), México). Alancaster-Ibarra, Assoc. Mexicana Geol. Petroleros Bol., v. 3, p. 207, fig. 15, 1951 (Miocene, México).

Cardium (*Laevicardium*) cf. *C. serratum* Linné, Hubbard, New York Acad. Sci., Scientific Survey of Porto Rico and Virgin Islands, v. 3, no. 2, p. 114, 1920 (Oligocene and Miocene, Puerto Rico).

Laevicardium sublineatum (Conrad), Böse, Inst. Geol. México Bol. 22, p. 25, 79, pl. 11, fig. 4, 1906 (Miocene, México). Alancaster-Ibarra, Cong. Cient. Mex. Mem., v. 3 (Cienc. Fisicas y Matemáticas, Geol.), p. 65, 1953 (Miocene, México).

Cardium (*Laevicardium*) *Dalli* Toula, K. k. Geol. Reichsanstalt Jahrb., v. 58, p. 722, pl. 27, fig. 6, 1909 (Miocene, Canal Zone). Not *Cardium dalli* Heilprin, 1887. Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 63, p. 367, 1911 (Miocene, Canal Zone; Toulas record, cited as a homonym).

Cardium gorgasi Hanna, California Acad. Sci. Proc., 4th ser., v. 13, no. 10, p. 160, 1924 (Miocene, Canal Zone). Substitute name for *Cardium* (*Laevicardium*) *Dalli* Toula.

Cardium (*Laevicardium*) *gorgasi* Hanna, Anderson, California Acad. Sci. Proc., 4th ser., v. 18, no. 4, p. 165, 1929 (Miocene, Colombia).

?*Cardium* (*Laevicardium*) *venustum* Gabb, Am. Philos. Soc. Trans., n. ser. v. 15, p. 251, 1873 (Miocene, Dominican Republic). Maury, Bull. Am. Paleontology, v. 5, no. 29, p. 213, pl. 36, fig. 9, 1917 (Miocene, Dominican Republic). Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 73, p. 421, pl. 25, figs. 2, 7, 1922 (Miocene, Dominican Republic). Anderson, California Acad. Sci. Proc., 4th ser., v. 18, no. 4, p. 166, 1929 (Miocene, Colombia).

Small to medium size, obliquely ovate, height slightly less than length to slightly more than length, decidedly inequilateral, posterior end narrower and more extended than anterior end, strongly convex. Umbo high and strongly inflated. Exterior polished. Fine hidden radial ribbing showing through exterior surface near ventral margin and more obscurely here and there elsewhere; conspicuous on corroded valves and present on internal molds. Left posterior cardinal tooth small and thin; left anterior lateral tooth closer to cardinal teeth than posterior lateral tooth. Hinge of right valve unknown.

Length 21.8 mm, height 22.8 mm, convexity 7.2 mm (figured immature left valve). Length 34 mm, height 32.8 mm, convexity (both valves) 21.5 mm (largest specimen).

The synonymy is designed to cover Caribbean fossil occurrences.

Laevicardium laevigatum was found in the three Miocene formations listed under "Occurrence", but is rare. All except two of the 11 specimens are internal molds, and none is large. The middle part of the Gatun formation at locality 155 yielded two immature shells—the illustrated left valve and a slightly smaller articulated specimen.

For many years, following Dall's lead, this species was known as *Cardium* (*Laevicardium*) *serratum*, but, according to Clench and L. C. Smith, in the publication cited in the synonymy, the proper name is *Laevicardium laevigatum*. Large, well-preserved shells are especially abundant at the middle Miocene locality near Santa Rosa in the Tehuantepec area (USGS 9995, 23737).

Occurrence: La Boca formation (early Miocene), Gaillard Cut area, localities 99b, 99g. Upper member of Alhajuela formation (early Miocene), locality 85. Lower and middle parts of Gatun formation (middle Miocene). Lower part, locality 138. Middle part, eastern area, localities 144a, 144c, 150, 155; western area, localities 160, 165. Lares limestone (late Oligocene), Puerto Rico (Hubbard's record). Quebradillas (now Aymamón) and Ponce limestones (early Miocene), Puerto Rico. Cercado and Gurabo formations (middle Miocene), Dominican Republic. Bowden formation (middle Miocene), Jamaica. Agueguexquite formation (middle Miocene), Tehuantepec area, México. Deposits of middle Miocene age, Limón Province, Costa Rica. Tubará (middle Miocene) and Usiacurí (late Miocene) formations, Colombia. Springvale formation (late Miocene), Trinidad. Point Courbaril member of Morne l'Enfer formation (early Pliocene), Trinidad. Moín formation (late Pliocene), Costa Rica. Miocene to Pliocene, southeastern United States. Living, North Carolina to Paraná, Brasil.

Family MACTRIDAE

Subfamily MACTRINAE

Unidentified mactrine mactrids are listed under the La Boca formation and the upper member of the Alhajuela formation.

Genus Eopapyrina Woodring, n. gen.

Type: *Mactra* (*Mactrella?*) *darienensis* Dall, Eocene, Canal Zone.

Of medium size, thin-shelled, triangular-ovate, length generally greater than height. Generally inequilateral, anterior end more extended than posterior. Valves apparently slightly gaping at extreme ventral end of posterior margin. Umbo high, wide, strongly convex. Posterior slope narrow, set off by subdued carina. Closely spaced, narrow concentric threads on anterior and posterior ends (on posterior end generally on dorsal part); remainder of shell bearing subdued growth lines. Hinge unknown.

Through the hinge of *Eopapyrina* is unknown, there is no reasonable doubt that the genus is a mactrid, and it probably is a small predecessor of *Mactrellona*. It is less elongate than *Mactrellona*, and the posterior slope is set off by a subdued carina, instead of a sharp, or even serrate, carina.

Eopapyrina darienensis (Dall)

Plate 87, figures 3, 5, 6, 10

Mactra (*Mactrella*?) *darienensis* Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 4, p. 895, 1898 (Eocene, Canal Zone).

Mactra dariensis [*darienensis*] Dall, Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 63, p. 371, 1911 (Eocene, Canal Zone; Dall's record).

Not *Mactra dariensis* [*darienensis*] Dall, Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 73, p. 427, 1922 (Miocene(?), Dominican Republic).

Features of the genus, which is monotypic.

Length (almost complete) 30 mm, height 26 mm, convexity about 9 mm (largest figured valve, largest specimen). Length (almost complete) 21 mm, height 20 mm, convexity about 7 mm (type).

Type (right valve) USNM 112271.

Type locality: 40, Vamos Vamos, Canal Zone, a locality off Palenquilla Point submerged by Gatun Lake, marine rocks of late Eocene age.

The heretofore unillustrated type (pl. 87, fig. 6) was forwarded by Alexander Agassiz in 1891 in a piece of rock containing also the type of *Glyptostyla panamensis.*

This species is abundant in collections from Vamos Vamos and Palenquilla Point and occurs also on Trinidad Island: a total of 160 specimens, ranging in length from 6.5 to 30 mm. Though they are internal molds, a considerable number retain bits or larger parts of the shell. The best preservation is afforded by the virtual topotypes from Palenquilla Point. The sculpture on the ends of the shell is shown on plate 87, figure 5.

Eopapyrina darienensis occurs also in the Búcaro formation of Sapper (1937) of the Tonosí area in southwestern Panamá, where it reaches a slightly larger size than in the Canal Zone (length 36 mm).

Occurrence: Marine rocks of late Eocene age, localities 40, 40a, 40d, 40e, 41, 41a, 41b, 42. Búcaro formation (late Eocene), Tonosí area, Los Santos Province, Panamá (USGS 6586c).

Mactrellona Marks

Marks, Bull. Am. Paleontology, v. 33, no. 139, p. 85.

Type (orhtotype): *Mactra alata* Spengler, living western Atlantic Ocean, Jamaica to Puerto Rico, Nicaragua to Paraná, Brasil [and eastern Pacific Ocean, Nicaragua to Ecuador].

Mactrellona was known for many years as *Mactrella* (Gray, 1853, p. 41; type (monotype): *M*[*actrella*] *striatula* [Linné], (*Mactra striatula* Linné), living, Philippines). Hanley's (1855, p. 55, pl. 2, fig. 3) description and illustration of Linné's specimen of the type species show that it has nothing to do with *Mactra alata.* Mörch's (Catalogus conchyliorum * * * Comes de Yoldi, pt. 2, p. 4, Copenhagen, April, 1853) *Papyrina* was available for *Mactra alata* until Keen (1969, p. N598) designated *Mactra striatula* as its type species, making it an objective synonym of *Mactrella.* Though Gray's and Mörch's names were published in the same year, Gray's has 3 months priority.

Mactrellona alata (Spengler)

Plate 115, figures 17, 18

Mactra alata Spengler, Skrivter Naturhistorie-Selskabet, v. 5, pt. 2, p. 99, 1802 (living, South America). Reeve, Conchologia iconica, v. 8, *Mactra*, pl. 8, fig. 29, and acompanying text, 1854 (living, "West Columbia"). Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 263 (assigned to subgenus *Mactrella*), pl. 28, fig. 3, 1922 (Miocene, Costa Rica). Pilsbry and Olsson, Acad. Nat. Sci. Philadelphia Proc., v. 93, p. 73, 1941 (Pliocene, Ecuador).

Mactrella alata (Spengler), Henry and Arthur Adams, The genera of Recent Mollusca, v. 2, p. 377, 1856; pl. 101, figs. 3, 3a, 1858 (living, South America).

Mactrellona alata (Spengler), Olsson, Mollusks of the tropical eastern Pacific; Panamic-Pacific Pelecypoda, p. 327 pl. 56, fig. 4, Paleontological Research Inst., 1961 (living, Nicaragua to Ecuador).

?*Mactra* (*Mactrella*) cf. *alata* Spengler, Maury, Bull. Am. Paleontology, v. 5, no. 29, p. 231, 1917 (Miocene, Dominican Republic).

?*Mactella alata* (Spengler), Gabb, Am. Philos. Soc. Trans., n. ser., v. 15, p. 248, 1873 (Miocene(?), Dominican Republic).

?*Labiosa* (*Labiosa*) cf. *alata* (Spengler), Haas, Jour. Paleontology, v. 16, p. 309, 1942 (Miocene, Costa Rica).

Large, thin-shelled, triangular-ovate, length greater than height. Slightly inequilateral, anterior end slightly more extended than posterior. Umbo high, wide, strongly convex. Posterior slope narrow, set off by sharp nonserrate carina; middle part of slope swollen. Closely spaced, narrow concentric threads on dorsal part of anterior end and on posterior slope between swollen middle part and shell margin; remainder of shell bearing more or less emphasized growth lines. Hinge unknown, except left anterior cardinal teeth, united to form inverted V, chondrophore, and short, very narrow ligament area.

Length (almost complete) 68.7 mm (estimated restored length 75 mm), height 51.5 mm, diameter (both valves) 31.5 mm (figured specimen). Length (incomplete) 68 mm (estimated restored length 80 mm), height 64 mm, diameter about 18 mm (largest specimen).

Type: Presumably at University Zoological Museum, Copenhagen.

Type locality: Living, South America, presumably Brasil.

Six specimens of this mactrid were found in the middle part of the Gatun formation: four internal molds (two of which are molds of articulated valves), a large incomplete left valve, and an umbonal fragment of a left valve. The large left valve shows the sculpture on the ends of the shell—a feature shown by *Eopapyrina*, but not any available living Caribbean shells of *Mactrellona alata*. The extreme ventral part of the posterior margin of all the specimens from the Gatun is missing, so that the presence or absence of the short narrow gape of living Caribbean shells is indeterminable.

None of the Miocene Caribbean specimens so far recorded has a serrate carina. The carina of some living Caribbean shells, however, is not serrate, and that of the living eastern Pacific shell illustrated by Olsson also is not serrate.

Mactra (*Mactrella*) *tumbezia* (Olsson, 1921, p. 66, pl. 9, figs. 3, 5; Oligocene, Perú, Ecuador) is intermediate in size between *Eopapyrina* and *Mactrellona*, but the carina suggests *Mactrellona*.

Occurrence: Middle part of Gatun formation (middle Miocene), eastern area, localities 143, 144a, 153, 155c; western area, locality 160. Middle Miocene deposits, Limón Province, Costa Rica. Jama and Canoa formations (Pliocene), Ecuador. Living, western Atlantic and eastern Pacific Oceans, as specified under heading *Mactrellona*.

Genus? cf. Mulinia

Small, *Mulinia*-like. Ovate, length and height almost equal, subequilateral, moderately to strongly convex. Umbo high, wide, convex. Anterior margin more broadly rounded than posterior. Slight angulation setting off narrow posterior slope. Practically smooth. Hinge unknown.

Length 19.3 mm, height (almost complete) 17.7 mm, convexity (both valves) about 10 mm (most convex specimen).

Three poorly preserved specimens from the marine rocks of late Eocene age are assigned to an unidentified genus. They are internal molds retaining much of the shell material. If they represent one species, as seems probable, a considerable range of variation in convexity is apparent. Though they are more or less *Mulinia*-like, they may represent some other genus descended from a Cretaceous genus, such as *Cymbophora*, *Priscomactra*, or *Mulinoides*.

Occurrence: Marine rocks of late Eocene age, localities 40a, 40d, 42.

Genus Mulinia Gray

Gray, Mag. Nat. History, new ser., v. 1, p. 375, 1837.

Type (orthotype, Internat. Code Zoological Nomenclature, art. 68, i): *M*[*ulina*] *typicus* Gray=*Mactra edulis* King and Broderip, living, Chile.

Mulinia aff. M. lateralis (Say)

Plate 114, figure 7

Small, triangular-ovate, length slightly greater than height, subequilateral. Umbo high, wide, strongly convex. Posterior slope narrow, set off by subdued angulation. Sculpture of more or less distinct growth lines. Hinge shown by two very small valves (locality 138c): no ligament; anterior lateral teeth close to cardinal teeth, posterior lateral teeth slightly farther from chondrophore.

Length (almost complete) 11.4 mm, height 8.5 mm, convexity 3.5 mm (figured right valve). Length 18.5 mm, height 13.9 mm, convexity 4.5 mm (largest valve).

The small Miocene, Pliocene, and living species of *Mulinia* in eastern and southeastern United States are burdened with many names. Most of those for the fossils have been used subjectively, depending on locality and age.

Fourteen unsatisfactory specimens from the lower and middle parts of the Gatun formation are identified as *M.* aff. *M. lateralis*. In size they agree with the living *M. lateralis*, the age range of which extends back to the Miocene. *M. lateralis sauryensis* has been described from the middle Miocene of Limón Province, Costa Rica (Olsson, 1922, p. 265, pl. 28, figs. 23, 24).

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, localities 138a, 138c, 138d, 138f. Middle part, eastern area, locality 139b.

Mulinia aff. M. cleryana (d'Orbigny)

Plate 116, figure 24

Similar to preceding species, but of medium size. Growth lines irregularly emphasized. Hinge unknown.

Length 31.5 mm, height 27.5 mm, convexity about 9.5 mm (figured left valve).

A left valve collected from the middle part of the Gatun formation is the only *Mulinia* of medium size in the faunas under study. The posterior part of the shell is missing, except in the umbonal area. Nevertheless, this fossil strongly suggests the living Caribbean species, *M. cleryana* (d'Orbigny, 1847, p. 510, (1846)). Altena (1971, p. 51, pl. 4, figs. 13–15) compared his specimens from Surinam with d'Orbigny's unillustrated type, which was collected near Rio de Janeiro. The species now ranges from Hispaniola to Santa Catarina, Brasil.

This is the largest fossil *Mulinia* so far recorded from the present Caribbean region. No fossil or living species from that region is as large as the Panamic *M. pallida* (Broderip and Sowerby), which reaches a length of 72 mm.

Occurrence: Middle part of Gatun formation (middle Miocene), western area, locality 161c. Tubará formation (middle Miocene), Atlántico Dept., Colombia (USGS 11355). Usiacurí formation (late Miocene), Atlántico Dept., Colombia (USGS 11360).

Genus Trinitasia Maury

Maury, Science, v. 67, no. 1734, p. 318, 1928.

Type (orthotype): *Thyasira sanctiandreae* Maury, Miocene, Trinidad.

The type species (Maury, 1925a, p. 166, pl. 30, figs. 2, 3; San Jose silt member of Manzanilla formation, late middle Miocene) was assigned to *Thyasira* on the advice of Dall, as quoted by Maury. She later thought that a specimen from an unspecified locality in northern South America (presumably in Venezuela) showed three cardinal teeth and proposed the name *Trinitasia* without family allocation.

Weisbord (1929, p. 15, pl. 3, fig. 2) described as *Dermatomya*? *harrisi*, a species from the Tubará formation of Colombia. About 3 months later, Anderson (1929, p. 175, pl. 20, figs. 1–3) described *Mactra* (*Mulinia*?) *atlanticola* from the same formation. Both taxa are synonyms of *Trinitasia sanctiandreae*.

R. W. Barker, of Caribbean Petroleum, presented to the USNM two articulated specimens of *T. sanctiandreae* (USNM 561575), of early middle Miocene age, collected on Quebrada Lambedero, near Mene Saladillo, in the state of Zulia, Venezuela.

Among 11 topotypes, or virtual topotypes, of Weisbord's and Anderson's taxa in USNM collections, a right valve (USNM 647619) shows a mactrid hinge, as already noted (Woodring, 1974, p. 212). The cardinal teeth are mutilated, the chondrophore is fairly large, and the paired posterior lateral teeth are closer to the chondrophore than the paired anterior lateral teeth. Anderson (1929, p. 176) must have seen at least part of the hinge of his species, as he wrote "the hinge reveals its generic class."

Trinitasia aff. T. sanctiandreae (Maury)

Plate 93, figures 2, 4

Of medium size, thin-shelled, trigonal-ovate to trigonal-subelliptical, height 75 to 87 percent of length. Practically equilateral or inequilateral; if inequilateral, anterior end more extended than posterior. Strongly convex. Umbo high, full. Lunular flattened area partly preserved on largest valve. Anterior dorsal margin concave; posterior dorsal margin straight. Anterior end broadly rounded, posterior end more narrowly rounded, subtruncated. Sculpture of irregularly spaced growth lines, most conspicuous at posterior end. Interior inaccessible.

Length 48 mm, height 36 mm, convexity about 9 mm (larger figured valve). Length (practically complete) 38.5 mm, height 33.5 mm, convexity about 8 mm (smaller figured valve).

On the basis of the strong convexity, prosogyrate umbo, thin shell, and remnant of lunular flattened area, three left valves from the Culebra formation are assigned to *Trinitasia*. Two valves, one of which is illustrated (pl. 93, fig. 4), are short, trigonal-ovate, and practically equilateral, like the 14 available specimens of *T. sanctiandreae* from Trinidad, Venezuela, and Colombia (height 83 to 100 percent of length). The largest valve (pl. 93, fig. 2), however, is elongate, trigonal-subelliptical, and very inequilateral. The fossils from the Culebra are regarded as a predecessor of *T. sanctiandreae*. In addition to their greater range of variability in outline, their subtruncation of the posterior end is more distinct than on specimens of *T. sanctiandreae*.

Occurrence: Culebra formation (early Miocence), locality 108c.

Genus Ovamactra Woodring, n. gen.

Type: *Ovamactra cyma* Woodring, n. sp., Eocene, Canal Zone.

Of medium size, thin-shelled, ovate, length greater than height, equilateral, slightly convex. Anterior end more broadly rounded than posterior. Umbo low. Posterior slope very narrow. Narrow concentric undulations on about posterior fourth of mature shells (except on narrow posterior slope) and on about anterior fourth or fifth, generally not extending as far adventrally as on posterior part; exceptionally extending as far. Hinge unknown.

In the absence of the hinge, the affinities of this genus are uncertain. Despite the small size, ovate outline, and slight convexity, it may be related to *Harvella*, the following genus.

Ovamactra cyma Woodring, n. sp.

Plate 87, figures 1, 2

Features of the genus, which is monotypic.

Length 30.5 mm, height 21.2 mm, convexity about 5 mm (type, largest valve).

Type (right valve): USNM 135235.

Type locality: 40a (USGS 2683, Vamos Vamos, Canal Zone, a locality off Palenquilla Point submerged by Gatun Lake, marine rocks of late Eocene age.

Seventeen specimens of *Ovamactra cyma* were collected at Vamos Vamos and Palenquilla Point. All are internal molds that faithfully reflect the sculpture; the three from Vamos Vamos, including the type, retain most of the shell material.

Occurrence: marine rocks of late Eocene age, localities 40a, 41, 41a, 41b.

Genus Harvella Gray

Gray, Annals and Mag. Nat. History, 2d ser., v. 11, p. 42, 1853.

Type (monotype): *H[arvella] elegans* (Sow[erby]) (*Mactra elegans* Sowerby), living, Gulf of California to northern Perú.

This paciphile genus has been found in the Miocene of southeastern Costa Rica, Panamá, Colombia, and Trinidad, as well as in the Miocene of southwestern Costa Rica, Ecuador, and Perú, and in the Pliocene of western Nicaragua and Ecuador.

Poorly preserved internal molds from the La Boca formation are listed as *Harvella* sp.

Harvella elegans elegans (Sowerby)

Plate 116, figure 23

Mactra elegans Sowerby, Catalogue of shells in collection of Earl of Tankerville, app., p. 2, pl. 1, fig. 3, 1825 (living [eastern Pacific Ocean]).

Mactrella (Harvella) elegans (Sowerby), Anderson, California Acad. Sci. Proc., 4th ser., v. 18, no. 4, p. 176, pl. 21, figs. 5, 6, 1929 (Miocene, Colombia).

Harvella elegans (Sowerby), Olsson, Mollusks of the tropical eastern Pacific; Panamic-Pacific pelecypods, p. 329, pl. 56, figs. 5–5b, Paleontological Research Inst., 1961 (living, Gulf of California to northern Perú). Olsson, Neogene mollusks from northwestern Ecuador, p. 64, Paleontological Research Inst., 1964 (Miocene, Ecuador).

Mactra estrellana Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 263 (assigned to section *Harvella*), pl. 28, fig. 1, 1922 (Miocene, Costa Rica).

Mactra (Harvella) sanctiblasii Maury, Bull. Am. Paleontology, v. 10, no. 42, p. 114, pl. 21, fig. 2, 1925 (Miocene, Trinidad).

Of medium size, thin-shelled, triangular-ovate, length slightly greater than height, subequilateral, strongly convex. Umbo narrow, low. Lunular area cordate, wide. Posterior slope very narrow, set off by thin carina. Sculpture of strong, widely spaced concentric undulations, except on lunular area and posterior slope. More or less distinct narrow low concentric threads on and between undulations. Hinge not exposed.

Length 48.3 mm, height 43.8 mm, convexity (both valves) 29 mm (figured specimen). Length (incomplete) 47.5 mm (estimated restored length 57 mm), height 50 mm, convexity (both valves) 35.6 mm (largest specimen).

Type: Presumably at British Museum (Natural History).

Harvella elegans elegans is identified in the lower and middle parts of the Gatun formation. Though it was collected at nine localities, the only large specimens are in three collections, two from the same locality in the lower part of the Gatun (136 and 136a) and one from the middle part (155), a total of 12 specimens, all articulated. Four collections consist of immature valves, for the most part internal molds. The range in length for all 22 specimens is about 10 to an estimated 57 mm.

None of these fossils, or of other fossil representatives of this subspecies, is as large as living shells, which reach a length of 65 to 70 mm. Though the type of *H. estrellana* has a length of 50 mm, the largest in seven USNM lots from Río Banano, near the type locality, measures about 40 mm.

A very large subspecies, *H. elegans tucilla* (Olsson, 1932, p. 129, pl. 14, fig. 1; Pilsbry and Olsson, 1941, p. 75) has a length as great as 102 mm. It occurs in the late Miocene Tumbes formation of Perú, the Pliocene Jama formation of Ecuador, and the Pliocene El Salto formation of western Nicaragua. (For the El Salto formation, see Woodring, 1973 p. 187, list. When that account was prepared, the El Salto was considered to be of late Miocene or Pliocene age).

The outline of *Mactra sincola* (Olsson, 1922, p. 264, pl. 28, fig. 4), from the same formation that yielded the type of *H. estrellana*, indicates that it is to be assigned to *Harvella*, as was done by Olsson. If so, it is unique. In addition to concentric undulations, it is sculptured with narrow vermicular radial threads, such as are seen on well-preserved shells of *Raeta plicatella*, and *R. undulata*.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, localities 134, 136, 136a. Middle part, eastern area, localities 144d, 145, 147g, 155, 159c; western area, localities 160, 161c. Middle Miocene deposits, Limón Province, Costa Rica. Middle Miocene deposits, Río Sinú area, Córdoba Dept., Colombia (USGS 8755). Tubará formation (middle Miocene), Atlántico Dept., Colombia. Middle Miocene deposits, Trinidad (Maury's records). Usiacurí formation (late Miocene), Atlántico Dept., Colombia (USGS 11505). Borbón formation (late Miocene), Ecuador. Las Sierras formation (early Pliocene), Nicaragua (USGS 25091). Living, Gulf of California to northern Perú.

Subfamily PTEROPSELLINAE

Genus Raeta Gray

Gray, Annals and Mag. Nat. History, 2d ser., v. 11, p. 43, 1853.

Type (monotype): *R*[*aeta*] *campechensis* [(Gray)] (*Mactra campechensis* Gray, 1825 = *Lutraria plicatella* Lamarck, 1818), living, North Carolina to Argentina.

Raeta cf. R. gardnerae (Spieker)

Plate 91, figure 27

Small, thin-shelled, ovate, length greater than height. Subequilateral to inequilateral; if inequilateral, posterior end more extended than anterior. Anterior part of shell obliquely convex, posterior part compressed. Anterior margin broadly rounded, posterior margin less broadly rounded to subangulated. Umbo low, narrow. Sculpture of closely spaced low concentric rugae.

Length (incomplete 23.7 mm (estimated restored length 25 mm), height 20.2 mm, convexity about 5 mm (figured valve). Length 39.4 mm, height (incomplete) 28.5 mm (estimated restored height 30 mm), convexity about 10 mm (largest valve).

Three valves in a small collection of shallow-water mollusks from the Bohio formation of Barro Colorado Island and one from the moderately deep water facies of the Caimito formation, also of Barro Colorado, are identified as *Raeta* cf. *R. gardnerae.* The illustrated valve from the Bohio is the smallest of the three from that formation. It shows the sculpture to better advantage than the other two larger valves, one of which is subequilateral and the other inequilateral. The single valve from the Caimito closely resembles the illustrated small valve from the Bohio.

It is not a simple matter to attempt identification of small specimens of *Raeta*. Though the illustrated Canal Zone specimen resembles the small type of *R. gardnerae* (Spieker, 1922, p. 168, pl. 10, middle Miocene, Perú; length 27.5 mm), the rugae of the Canal Zone specimens are slightly more closely spaced. Olsson, who treated *R. gardnerae* as a subspecies of the much larger, living eastern Pacific *R. undulata,* illustrated a specimen larger than the type (Olsson, 1932, p. 133, pl. 14, fig. 4; length 43 mm).

R. gabbi (Pilsbry and Johnson) (Pilsbry, 1922, p. 427, pl. 46, fig. 11; unknown part of Miocene, Dominican Republic) and *R. undulata mirandana* (H. K. Hodson, *in* Hodson and Hodson, 1931a, p. 22, pl. 7, fig. 7; early Miocene, Venezuela) are more or less similar to *R. gardnerae.*

This is the first Oligocene record for *Raeta* so far known.

Occurrence: Bohio formation (late Oligocene), locality 42i. Caimito formation (late Oligocene), locality 54l.

Raeta hasletti (Anderson)

Plate 114, figures 12, 13

Labiosa (*Raeta*) *hasletti* Anderson, California Acad. Sci. Proc., 4th ser., v. 18, no. 4, p. 177, pl. 23, figs. 2, 3, 1929 (Miocene, Colombia).

Labiosa (*Raeta*) *gibbosa* (Gabb), Anderson, California Acad. Sci. Proc., 4th ser., v. 18, no. 4, p. 177, 1929 (Miocene, Colombia).

Labiosa (*Raeta*) *gardnerae* Spieker, Anderson, California Acad. Sci. Proc., 4th ser., v. 18, no. 4, p. 177, 1929 (Miocene, Colombia).

Of medium size, thin-shelled, ovate, length greater than height, subequilateral. Anterior part of shell strongly convex, posterior part somewhat compressed. Anterior margin more broadly rounded than posterior. Umbo low, wide. Sculpture of irregularly emphasized and irregularly spaced, low concentric rugae. Hinge not exposed.

Length 51.5 mm, height 38.5 mm, convexity (both valves) 24.5 mm (figured specimen).

Type: California Acad. Sci. 4674.

Type locality: California Acad. Sci. 267, north slope of Tubará Mountain, Atlántico Dept., Colombia, Tubará formation.

Raeta hasletti is represented by two articulated specimens found in the middle part of the Gatun formation at the Gatun Third Locks excavation. On both, the thin shell is missing in small patches.

In a collection of five articulated virtual topotypes (USGS 11344), a considerable range of variation is shown in the ratio of height to length, degree of compression of the posterior part of the shell, and regular or irregular development of the sculpture. The other two names used by Anderson for *Raeta* in the Tubará formation presumably were inspired by immature or untypical specimens of *R. hasletti,* which is fairly widespread in the Tubará (seven lots in USNM collections).

Occurrence: Middle part of Gatun formation (middle Miocene), locality 155. Tubará formation (middle Miocene), Atlántico Dept., Colombia.

Raeta undulata (Gould)

Plate 114, figures 17–19

Lutraria undulata (Gould), Boston Soc. Nat. History Proc., v. 4, p. 89, 1851 (living, La Paz, Gulf of California). Gould, Boston Jour. Nat. History, v. 6, p. 391, pl. 15, fig. 7, 1853 (living, Gulf of California).

Labiosa (*Raeta*) *undulata* (Gould), Hodson and Hodson, Bull. Am. Paleontology, v. 16, no. 59, p. 21, pl. 7, fig. 6, 1931 (Miocene, Venezuela). Pilsbry and Olsson, Acad. Nat. Sci. Philadelphia Proc., v. 93, p. 74 (Pliocene, Ecuador).

Labiosa (*Raeta*) *undulata undulata* (Gould), Olsson, Bull. Am. Paleontology, v. 19, no. 68, p. 131, pl. 14, fig. 11, 1932 (Miocene, Perú).

Raeta undulata (Gould), Olsson, Mollusks of the tropical eastern Pacific; Panamic-Pacific Pelecyoda, p. 332, pl. pl. 56, figs. 6–6b, Paleontological Research Inst., 1961 (living, southern California to northern Perú). Olsson, Neogene mollusks from northwestern Ecuador, p. 64, pl. 5, fig. 13, Paleontological Research Inst., 1964, (Miocene, Ecuador). Olsson and Petit Bull. Am. Paleontology, v. 47, no. 217, p. 533, pl. 78, fig. 6, 1964 (Miocene, Florida).

Raeta (*Raeta*) *undulata* (Gould), Harry, Veliger, v. 12, p. 14, fig. 13, 1969 (living, Topolobampa, México).

Raeta undulata undulata (Gould), Díaz de Gamero, Univ. Central Venezuela, Escuela Geol. Minas Metalurgía, Geos, no. 17, p. 37, pl. 3, fig. 6, 1968 (Miocene, Venezuela).

Anatina (*Raeta*) *undulata* (Gould), Marks, Bull. Am. Paleontology, v. 33, no. 139, p. 87, pl. 5, fig. 3, 1951 (Miocene, Ecuador).

Not *Labiosa* (*Raeta*) *undulata* (Gould), Barrios, Colombia, Servício Geol., Bol. Geol., v. 6, nos. 1–3 (Informe 1082), p. 261, pl. 7, fig. 10, 1960 (Miocene, Colombia).

Large, thin-shelled, ovate, length greater than height. Inequilateral, posterior end more extended than anterior. Anterior part of shell strongly convex, posterior part compressed. Anterior margin broadly rounded; dorsal part of posterior margin almost straight, ventral part of posterior margin more abruptly rounded than anterior margin. Umbo high, wide. Slight, narrow, radial swelling near posterior margin present or absent. Sculpture of two types: (1), narrow, closely, or more widely, spaced undulations, converted on ventral part of shell into low rugae of irregular width; (2), coarse, widely spaced undulations extending down on about four-fifths of shell height, or almost to ventral margin, before conversion into irregular rugae. Very fine, wavy, or even oblique, radial vermicular threadlets visible on at least ventral part of shell, except on worn specimen. Hinge not exposed.

Length 72 mm, height 53.7 mm, convexity (both valves) 36.5 mm (figured specimen).

Type: Mus. Comparative Zoology, Harvard Univ., 169453.

Type locality: La Paz, Gulf of California, living.

This large *Raeta* occurs in the upper part of the Gatun formation in the western area: four articulated specimens. The illustrated specimen has sculpture described as type 1. The more extended posterior end and the less pointed posterior ventral margin distinguish *R. undulata* from the very closely allied living western Atlantic *R. plicatella* (Lamarck) (Lamy, 1917, p. 353, pl. 7, fig. 6).

The three species of *Raeta* in the faunas under consideration are graded in increasing size with decreasing age, but they evidently do not constitute a lineage.

Occurrence: Upper part of Gatun formation, western area (middle Miocene), localities 182, 182a. Progreso formation (middle Miocene), Ecuador. Olsson's Pinecrest beds (late Miocene), Florida. El Veral formation (late Miocene), Falcón, Venezuela. Urumaco formation (middle or late Miocene), Falcón, Venezuela. Moctezuma formation (late Miocene), Costa Rica, USGS 24980. Borbón formation (late Miocene), Ecuador. Tumbes formation (late Miocene), Perú. Jama formation (Pliocene), Ecuador. Living, southern California to northern Perú.

Family MESODESMATIDAE

Subfamily ERVILIINAE

Genus Ervilia Turton

Turton, Conchylia Insularum Britannicarum, Dithyra, p. 55, 1822.

Type (monotype): *Mya nitens* Montagu, living, southern Florida, Bermuda, West Indies.

Ervilia species

Plate 87, figure 7

Of medium size for genus, trigonal-ovate, convex, height 77 to 80 percent of length. Equilateral or subequilateral; if subequilateral, posterior end slightly more extended than anterior. Anterior margin more broadly rounded than posterior. Sculpture of growth lines, some of which are emphasized. Hinge unknown.

Length 6.2 mm, height 4.8 mm, convexity about 2 mm (figured left valve).

Two valves from the marine rocks of late Eocene age are assigned to *Ervilia*, although the hinge is not known. The larger, which is illustrated, is subequilateral, whereas the smaller (length 3.6 mm) is equilateral.

This unnamed species is not similar to either of the two of Eocene age on record from southeastern United States. As in that area, no species of Oligocene age is so far recorded in the Caribbean region.

Occurrence: Marine rocks of late Eocene age, locality 41b.

Ervilia valhosierr Gardner

Plate 113, figures 1–3, 6

Ervilia valhosierr Gardner, U. S. Geol. Survey Prof. Paper 142–E, p. 225, pl. 34, figs. 6–9, 1928 (Miocene, Florida).

Of medium size to moderately large for genus, moderately to strongly convex, elongate-ovate to trigonal-ovate. Slightly to moderately inequilateral, posterior end more extended than anterior. Height about 60 to about 80 percent of length. Umbo low, narrow, and moderately convex on elongate-ovate valves; high, wide, and strongly convex on trigonal-ovate valves. Anterior margin more broadly rounded than posterior. Prodissoconch generally preserved. Exterior generally practically smooth, or bearing growth lines, some exaggerated; fairly regular concentric rugae on few immature valves. As usual, right cardinal tooth large.

Length 5.8 mm, height 3.7 mm, convexity 1.2 mm (figured left elongate-ovate valve). Length (incomplete) 7.5 mm (estimated restored length 8.5 mm), height 5.9 mm, convexity 2 mm (largest valve, elongate-ovate). Length 5 mm, height 4.1 mm, convexity 1.8 mm (figured left triangular-ovate valve).

Type material: 2 syntypes, a right and a left valve, USNM 352017.

Type locality: USGS 5079, Half a mile below Shell Bluff, Shoal River, Walton County, Fla., Shoal River formation.

Valves of the genus *Ervilia* that occur throughout the Gatun formation, except in the upper part in the western area, are interpreted to represent a variable species, for which the name *E. valhosierr* is adopted

The trigonal-ovate form (pl. 113, fig. 1) and a somewhat elongate form (pl. 113, fig. 3) were found in the lower part of the Gatun and are extraordinarily abundant at localities 138 and 138c, at both of which an estimated several hundred were collected. The umbo of the trigonal-ovate form is so convex that the prodissoconch is not visible in external view. A somewhat trigonal-ovate form, *E. triangularis* (Dall, 1890–1903, p. 915, pl. 33, fig. 19, 1898), is associated in the early Miocene Chipola formation of Florida with an elongate form, *E. chipolana* (Dall, 1890–1903, p. 914, pl. 33, fig. 10, 1898). On the contrary, a trigonal-ovate form of *E. valhosierr* is unknown in Florida, where the species occurs in the middle Miocene Shoal River formation.

The elongate form (pl. 113, fig. 2) occurs in the middle and upper parts of the Gatun, but not more than some 20 at any locality. It resembles *E. valhosierr,* although some Florida valves have a less rounded posterior end. Concentric sculpture (pl. 113, fig. 6) among the fossils from the Gatun was seen on a few immature valves and is absent on Florida specimens. Throughout the Gatun, articulated specimens are rare, especially in the large collections from the lower part of the formation.

Perhaps two species or subspecies are involved in these collections from Panamá. To compare the fossils from the Gatun with real or alleged other Miocene and later species from other localities would be excessively time-consuming, and the results are likely to be inconclusive. Too many names are available, especially for the fossils: 15 for the fossils and six for living western Atlantic representatives. Rooij-Schuiling (1973, p. 236) recently recognized only one species—*E. nitens*—in the western Atlantic Ocean.

The trivial name of this species is not a typographical error. As used by Gardner, it is to be treated as a noun in apposition.

Occurrence: Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, localities 137a, 138, 138a, 138b, 138c, 138d, 138e, 138f, 138g. Middle part, eastern area, localities 139c, 139e, 139f, 144a, 144c, 144d, 147h, 152, 155, 155a, 155c; western area, localities 161, 161c, 169, 170, 170a. Upper part, eastern area, locality 163, 172, 177b. Shoal River formation (middle Miocene), Florida.

Family SOLENIDAE

Incomplete specimens from the La Boca formation and the upper member of the Alhajuela formation are listed as unidentified solenids.

Genus Solen Linne

Linné, Systema naturae, 10th ed., p. 672, 1758.

Type (logotype, Schumacher, Essai d'un nouveau systeme des habitations des vers testacés, p. 124, Copenhagen, 1817): *Solen vagina* Lin[né], living, East Indies(?).

Subgenus Solena Morch

Mörch, Catalogus conchyliorum * * * Comes de Yoldi, pt. 2, p. 7, Copenhagen, 1853.

Type (logotype, Stoliczka, India Geol. Survey Mem., Palaeontologia Indica, Cretaceous fauna of southern India, v. 3, p. XVI, 1870): *Solen obliquus* Spengler, living, West Indies, Panamá to Salvador, Brasil.

Solen (Solena) obliquus rudis C. B. Adams

Plate 115, figure 13

Solen rudis C. B. Adams, New York Lyceum Nat. History Annals, v. 5, p. 524, 1852 (living, Panamá). Turner, Harvard Univ., Mus. Comp. Zoology, Dept. Mollusks, Occasional Papers on Mollusks, v. 2, no. 20, p. 83, pl. 19, figs. 1, 2, 1956 (living Panamá).

Solen (Solena) rudis C. B. Adams, Olsson, Mollusks of the tropical eastern Pacific; Panamic-Pacific Pelecypoda, p. 420, pl. 63, figs. 1, 1a, Paleontological Research Inst., 1961 (living, Costa Rica to Perú).

?*Solen* cf. *vagina* L[inné] Toula, K. k. Geol. Reichsanstalt Jahrb., v. 58, p. 732, 1909 (Miocene, Canal Zone).

?*Solen* spec., aff. *Solen vagina* L[inné], Toula, K. k. Geol. Reichsanstalt Jahrb., v. 61, p. 495, pl. 30, fig. 5, 1911 (Miocene, Canal Zone).

?*Solen* near *amphistemma* Dall, Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 64, p. 501 (list), 1913 (Miocene, Canal Zone).

Large, dorsal and ventral margins linear and parallel. Anterior margin asymmetrically rounded, ventral half somewhat extended. Posterior margin almost vertically truncated. Umbo located behind anterior end at about 1.6 percent of length of shell. Shallow depression extending obliquely forward from umbo to ventral margin on mature valves. Interior of shell thickened at anterior end. Exterior marked by growth lines, strongly exaggerated between depression and anterior end of shell. Hinge inaccessible.

Length 153 mm, height 26 mm, diameter (both valves) 17 mm (figured specimen).

Type: Lectotype, Mus. Comp. Zoology 186271.

Type locality: Panamá, Republic of Panamá, living.

Though 13 specimens of *Solen obliquus rudis* were collected from the lower and middle parts of the Gatun formation, that illustrated is the only complete one—complete aside from minor nicking at the posterior end.

S. rudis has been treated as a separate eastern Pacific species and as a synonym of *S. obliquus* Spengler, of the present Caribbean region. According to the grade of taxa adopted in the present account, they are classified as subspecies. The shallow oblique depression on mature valves distinguishes *S. obliquus rudis* from the nominate subspecies, which either lacks the depression, or it is barely suggested. In addition, *S. obliquus rudis* reaches a larger size, as large as 160 mm. The largest specimen of the nominate subspecies in USNM collections has a length of 120 mm; the largest in the type lot of *S. ambiguus* Lamarck, which is regarded as a synonym of *S. obliquus obliquus*, 127 mm (Lamy, 1932, p. 431).

The nominate subspecies extends back to early Miocene time in the Caribbean region.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, locality 138c. Middle part, eastern area, localities 139b, 139c, 139e, 157. Living, Costa Rica to Perú.

Family TELLINIDAE

Subfamily TELLININAE

Genus Tellina Linne

Linné, Systema naturae, 10th ed., p. 674, 1758.

Type (logotype, Schmidt, Versuch über die beste Einrichtung * * * vorzüglich der Conchylien-Sammlungen * * *, p. 51, 1818 (not seen, quoted from Boss, 1966–1968, pt. 1, p. 233, 1966)): *Tellina radiata* Linné, living, southern Florida to Guiana.

Boss' monograph of the western Atlantic tellinine tellinids (Boss, 1966–1968) has been used extensively in preparation of the present account.

Unidentified species or presumed species of *Tellina* are listed for the Gatuncillo, Bohio, and Caimito formations, Emperador limestone member of La Boca formation, and Gatun formation.

Subgenus Tellinella Morch

Mörch, Catalogus conchyliorum * * * Comes de Yoldi, pt. 2, p. 13, 1853; cited as *Tellinella* Gray.

Type (logotype, Stoliczka, India Geol. Survey Mem., Palaeontologia Indica, Cretaceous fauna of southern India, vol. 3, p. 116, 1870): *Tellina virgata* Linné, living, western Pacific Ocean.

Tellina (Tellinella) protera Woodring, n. sp.

Plate 91, figures 20, 21

Of medium size, elongate, height almost 40 percent of length, almost equilateral. Anterior margin narrowly rounded, posterior margin pointed. Narrow carina setting off narrow posterior slope; slight depression in front of carina. Sculpture of narrow, fairly widely spaced concentric lamellae and faint, closely spaced radial threadlets, not affecting concentric threads, or barely affecting them. Concentric lamellae slightly insinuated in depression in front of carina. Interior unknown.

Length (practically complete) 38.5 mm, height 14.8 mm, convexity about 5 mm (type). Length (incomplete) 21 mm (estimated restored length 25 mm), height 10.5 mm, convexity about 3 mm (paratype).

Type (left valve): USNM 647535; paratype (right valve) USNM 647536.

Type and paratype locality: 42d (USGS 18837, northern part of Barro Colorado Island, stream heading west of Miller Trail near Miller 17, about 100 m above mouth, Canal Zone), Bohio formation.

A marine lens in the upper part of the Bohio formation of Barro Colorado Island yielded three valves of *Tellina protera*—the type and two immature valves, one of which is the paratype. The type is an internal mold, on which the sculpture is shown on small bits of shell and in the umbonal area is impressed on the mold. On the almost complete immature paratype the shell, recrystalized to calcite, is preserved.

T. protera, the earliest species of *Tellinella* so far recorded in the Caribbean region, is like a miniature *T. listeri* Röding (Boss, 1966–68, pt. 1, p. 243, pl. 133, figs 1–3, pl. 134, fig. 1, 1966), living in the Caribbean province. The living species reaches a length of 83 mm. Though the spacing of its concentric threads is variable, they generally are more closely spaced than on the fossils. The living Panamic *T. cumingii* Hanley (Olsson, 1961, p. 379, pl. 68, fig. 13, pl. 69, fig. 3) is very closely allied to *T. listeri*.

Occurrence: Bohio formation (late Oligocene), locality 42d.

Tellina (Tellinella) cf. T. rovala Olsson

Plate 122, figure 1

Two right-valve internal molds of a *Tellinella* of medium size were found in the Chagres sandstone. The imprint of sculpture is more distinct on the illustrated valve, although it is less complete than the other. The concentric lamellae are more closely spaced than those of the preceding species, and no trace of radial threadlets is apparent. In those features and in size, this species is similar to *T. rovala* (Olsson, 1922, p. 249, pl. 26, figs. 7, 8; Limónes formation, Bocas del Toro area, Panamá).

Length (incomplete) 32.9 mm (estimated restored length 38 mm), height (incomplete) 15.5 mm (estimated restored height 17 mm), convexity about 6 mm (figured valve). Length (practically complete) 36.5 mm, height (practically complete) 16 mm, convexity about 5.5 mm (larger valve).

An incomplete external mold of a right valve from the Toro limestone member of the Chagres is listed as *Tellina* sp. Its lamellae are more widely spaced than those on the molds from the Chagres proper.

Occurrence: Chagres sandstone (late Miocene or early Pliocene), locality 201.

Subgenus Arcopagia Brown

Brown, Illustrations of the conchology of Great Britain and Ireland, pl. 16, figs. 8–10, London, 1827.

Type (logotype, Hermannsen, Indicis generum malacozoorium, v. 1, p. 76, Cassel, 1846): *Tellina crassa* Pennant, living, eastern North Atlantic Ocean.

Tellina (Arcopagia) cf. T. eburneopsis Conrad

Plate 85, figure 1

Small, suborbicular-ovate, height almost equal to length. Inequilateral, anterior end more extended than posterior. Posterior end slightly bent. Suggestion of slight radial swelling near posterior end. Interior unknown.

Length 20.3 mm, height 17.5 mm, convexity (both valves) 7 mm (figured specimen).

Two internal molds of articulated valves of a small *Arcopagia* from limestone of the Gatuncillo formation are similar in outline to *Tellina eburneopsis* (Harris, *in* Harris and Palmer, 1946–1947, pt. 1, p. 100, pl. 21, figs. 19, 20, 1946), a late Eocene species from southeastern United States. The fossils from the Gatuncillo are half as large as that species.

Occurrence: Gatuncillo formation (late Eocene), locality 9.

Tellina (Arcopagia?) acares Woodring, n. sp.

Plate 90, figures 5, 6

Very small, suborbicular-ovate, height almost equal to length. Inequilateral, anterior end more extended than posterior. Moderately convex. Anterior dorsal margin slightly concave near umbo on largest specimen, otherwise slightly convex; posterior dorsal margin barely convex. Anterior lateral margin broadly rounded; posterior lateral margin more narrowly rounded. Sculpture limited to closely spaced, or irregularly spaced, striae on ventral part of valve. Interior unknown.

Length 9 mm, height 7.3, convexity about 3 mm (type, largest specimen). Length 7.9 mm, height 6.7 mm, convexity about 1.5 mm (paratype).

Type (left valve): USNM 647578; paratype (right valve) USNM 647579.

Type and paratype locality: 41b (18839, east side of Palenquilla Point, head of cove north of triangulation station and southwest of Corozo Island, Canal Zone), marine rocks of late Eocene age.

This very small *Tellina* is represented by 30 specimens from the marine rocks of late Eocene age, all except seven of which were collected at Palenquilla Point. In outline it suggests *T. denudata* Deshayes (Cossmann and Pissarro (1904–1906, pl. 7, fig. 35–38; Cuisian of Paris basin), which is almost twice as large.

Occurrence: Marine rocks of late Eocene age, localities 40d, 40e, 41b.

Subgenus Phyllodina Dall

Dall, U. S. Natl Mus. Proc., v. 23, no. 1210, p. 290, 1900.

Type (orthotype): *Tellina squamifera* Deshayes, living, North Carolina to Florida and Gulf of Mexico.

Tellina (Phyllodina) lepidota Dall

Plate 116, figures 5, 6, 11, 12

Tellina (Phyllodina) lepidota Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 5, p. 1022, pl. 46, fig. 18, 1900 (Miocene, Canal Zone).

Tellina lepidota Dall, Brown, and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 63, p. 368, 1911 (Miocene, Canal Zone, Dall's record). Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 251 (assigned to section *Phyllodina*), pl. 26, figs. 4, 5, 1922 (Miocene, Panamá).

Small, thin-shelled, elongate-subelliptical, ventral part of posterior margin rounded-subtruncated. Low wide carina near posterior end. Right valve slightly convex. Prodissoconch swollen. Right valve sculptured with sharp concentric lamellae. First lamella appearing at height of 1.5 to 2 mm. Earliest lamellae widely spaced; spacing later decreasing in width, becoming regularly spaced on largest valve. Lamellae generally foliaceous at and near dorsal margins; supplementary lamellae added at and near anterior dorsal margin of early part of valve. Faint microscopic radial lineation between lamellae on main early part of valve. Hinge of right valve: narrow anterior and wider bifid posterior cardinal teeth; long strong anterior lateral tooth close to anterior cardinal, shorter posterior lateral tooth far from posterior cardinal. Pallial sinus indistinct. Left valve unknown.

Length 21 mm, height 11.5 mm, convexity about 2 mm (larger figured valve, largest specimen). Length (incomplete) 8.7 mm (estimated restored length 10.5 mm), height 5.2 mm (type).

Type (right valve): USNM 106933.

Type locality: 177 (Monkey Hill [Mount Hope], near Gatun, Canal Zone), upper part of Gatun formation.

Tellina lepidota is rare in the faunas under consideration: five right valves from the middle part of the Gatun formation and three right, including the small incomplete type, from the upper part in the eastern area. The type was broken recently in cleaning. Though it was repaired, it has not been photographed, to avoid the risk of further damage. Instead, Dall's illustration is reproduced.

T. dodona Dall, of the Oak Grove sand member of the Shoal River formation of Florida, reaches a length of 33.3 mm. Right valves, as shown by an immature valve in Dall's original lot and the large topotype illustrated by Gardner (1926–47, p. 192, pl. 29, figs. 8, 9, 1928), are less convex than left and are much more sharply sculptured. The sculpture of left valves is shown by the immature type (Dall, 1890–1903, pl. 30, fig. 7, 1898), and the large specimen mentioned by Dall in his description (Dall, 1890–1903, p. 1023, 1903) and illustrated by Gardner (1926–47, pl. 29, figs. 10, 11, 1928). The right-valve sculpture is like that of *T. lepidota,* except that the first lamella of *T. dodona* appears at an earlier stage. That species has been identified in the Agueguexquite formation of the Tehuantepec area (Perrilliat Montoya, 1963, p. 14, pl. 3 figs. 4, 13).

Olsson's right valve of *T. lepidota* from the Bocas del Toro area is less convex than the left. Though the left valve is less sharply sculptured than the right, it is more sharply sculptured than the left of *T. dodona.*

Boss (1966) attempted to trace back to the Miocene the lineage of the four living species of *Phyllodina.* He evidently was unaware of the discrepantly sculptured valves of *T. dodona* and *T. lepidota,* at least so far as *T. lepidota* is represented in the Bocas del Toro area.

Occurrence: Middle and upper parts of Gatun formation (middle Miocene). Middle part, eastern area, localities 147e, 147f, 157, 159d. Upper part. eastern area, localities 177, 177c. Limónes formation (late Miocene), Bocas del Toro area, Panamá.

Subgenus Merisca Dall

Dall, U. S. Nat'l Mus. Proc., v. 23, no. 1210, p. 290, 1900.

Type (orthotype): *Tellina crystallina* Wood [*Tellina cristallina* Spengler], living, western Atlantic Ocean, South Carolina to Virgin Islands; eastern Pacific Ocean, Panamá to Ecuador.

Tellina (Merisca?) pycna Woodring, n. sp.

Plate 91, figure 13

Of medium size, broadly triangular-ovate, height 76 percent of length. Slightly inequilateral, anterior end more extended than posterior, and anterior part of valve more convex than posterior. Anterior margin broadly rounded; posterior margin narrowly rounded. Suggestion of slight radial swelling near posterior end. Shell preserved on narrow rim around margin of much of valve. Subdued concentric lamellae showing on posterior dorsal part of rim near umbo; elsewhere on rim no sculpture apparent, other than growth lines. Interior and left valve unknown.

Length 22 mm, height 16.8 mm, diameter about 4 mm (type).

Type (right valve): USNM 647542.

Type locality: 42f (USGS 18836, northern part of Barro Colorado Island, stream southeast of Fuertes House, about 335 m above mouth, from slide on west side of stream, Canal Zone), upper part of Bohio formation.

The type, from a marine lens in the upper part of the Bohio formation of Barro Colorado Island, is the only specimen of *Tellina pycna.* It is an internal mold of a right valve that retains patches of inner shell material and a narrow outer rim of outer shell.

The outline suggests *Merisca*, but the apparent absence of well-developed concentric sculpture throws doubt on that assignment.

Occurrence: Bohio formation (late Oligocene), locality 42f.

Tellina (Merisca) cristallina Spengler

Plate 115, figure 2

Tellina cristallina Spengler, Skrivter Naturhistorie-Selskabet, v. 4, pt. 2, p. 113, 1798 (living, Newport, Long Island [corrected to Saint Thomas, Virgin Islands by Boss, 1966–68, pt. 1, p. 262, 1966]).

Tellina (*Merisca*) *cristallina* Spengler, Weisbord, Bull. Am. Paleontology, v. 45, no. 204, p. 343, pl. 49, figs. 13, 14, pl. 50, figs. 1, 2, 1964 (Pliocene, Venezuela). Boss, Johnsonia, v. 4, no. 45, p. 263, pl. 138, figs. 1–4, pl. 139, fig. 5, 1966 (living, South Carolina to Virgin Islands).

Merisca crystallina [*cristallina*] (Spengler), Olsson, Mollusks of the tropical eastern Pacific; Panamic-Pacific Pelecypoda, p. 382, pl. 70, figs. 2, 2a, Paleontological Research Inst., 1961 (living, Dominican Republic).

Tellina (*Merisca*) *crystallina* Chemnitz, Maury, Bull. Am. Paleontology, v. 5, no. 29, p. 223, pl. 38, fig. 4, 1917 (Miocene, Dominican Republic).

Tellina crystallina Wood, Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 249 (assigned to section *Merisca*), pl. 26, fig. 10, 1922 (Miocene, Costa Rica).

Tellina (*Merisca*) *crystallina* Wood, Pilsbry and Olsson, Acad. Nat. Sci. Philadelphia Proc., v. 93, p. 68, 1941 (Pliocene, Ecuador).

Tellidora crystallina Chemnitz, Gabb, Am. Philos. Soc. Trans., new ser., v. 15, p. 249, 1873 (Miocene, Dominican Republic).

Tellina errati Pilsbry and Johnson, Acad. Nat. Sci. Philadelphia Proc., v. 69, p. 201, 1917 (Miocene, Dominican Republic). Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 73, p. 425, pl. 41, fig. 7, 1922 (Miocene, Dominican Republic).

Merisca rhynchoscuta Olsson, Mollusks of the tropical eastern Pacific; Panamic-Pacific Pelecypoda, p. 382, pl. 70, figs. 3–3b, Paleontological Research Inst., 1961 (living, Panamá to Ecuador).

Small, broadly triangular-ovate, height 85 percent of length, practically equilateral, slightly convex. Posterior end strongly carinate; depression in front of carina. Anterior dorsal margin practically straight; anterior lateral margin broadly rounded; posterior margin slightly concave; ventral margin broadly rounded, insinuated along depression in front of carina. Suggestion of widely spaced concentric lamellae impressed on internal mold. Interior and left valve unknown.

Length 10 mm, height 8.5 mm, convexity about 1.5 m (figured internal mold of right valve).

Type: University Zoological Museum, Copenhagen.

Type locality: See under heading *Merisca*.

Though the only specimen is an internal mold, it is identified with considerable confidence as an immature *Tellina cristallina*. That species has been found in middle Miocene deposits in southeastern Costa Rica and the Dominican Republic.

For many years, following Dall's lead, *T. cristallina* has been identified in the western Atlantic and eastern Pacific Oceans. Olsson (1961), however, has proposed the name *Merisca rhynchoscuta* for the eastern Pacific representatives. In view of variation in both sets of populations, that taxon is not justified.

Occurrence: Middle part of Gatun formation (middle Miocene), western area, locality 165. Cercado formation (middle Miocene), Dominican Republic. Deposits of middle Miocene age, Limón Province, Costa Rica. Mare formation (early Pliocene), Venezuela. Canoa formation (Pliocene), Ecuador. Living, see under heading *Merisca*.

Tellina (Merisca) aequistriata Say

Plate 117, figures 22, 23

Tellina aequistriata Say, Acad. Nat. Sci. Philadelphia Jour., v. 4, p. 145, pl. 10, fig. 7, 1824 (Miocene, Maryland). Glenn, Maryland Geol. Survey, Miocene, p. 297, pl. 72, fig. 13, 1904 (Miocene, Maryland(?), Virginia.

Tellina (*Merisca*) *aequistriata* Say, Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 5, p. 1020, 1900 (Miocene, Jamaica; Miocene to Holocene, southeastern United States). Gardner, U.S. Geol. Survey Prof. Paper 142–E, p. 192, pl. 29, fig. 6 (Glenn's illustration), 1928 (Miocene, Florida). Mansfield, Florida Geol. Survey Bull. 8, p. 137, pl. 29, figs. 10, 11, 1932 (Miocene, Florida). Boss, Johnsonia, v. 4, no. 45, p. 267, pl. 139, fig. 1, pl. 141, figs. 1, 2, pl. 142, figs. 1–3 (explanations for pls. 141 and 142 transposed), 1966 (living, southern Florida to Bahia, Brasil).

Tellina (*Merisca*) sp., Woodring, Carnegie Inst. Washington Pub. 366, p. 171, 1925 (Miocene, Jamaica).

Small, broadly triangular-ovate, height about 73 percent of length. Moderately inequilateral, anterior end more extended than posterior; moderately convex. Anterior dorsal margin slightly concave adjoining strongly convex umbo, remainder slightly convex, merging into broadly rounded anterior lateral margin. Posterior margin straight, so far as preserved. Posterior ventral part of valve missing. Slight depression adjoining preserved part of posterior margin. Sculpture of high, narrow, closely spaced concentric lamellae. Hinge of left valve: bifid anterior and very thin posterior cardinal teeth; lateral teeth absent, slight thickening of valve margins taking their place. Pallial sinus extending beyond break in valve, upper limb high in valve.

Length (incomplete) 9.9 mm (estimated restored length 11.5 mm), height 8.5 mm, convexity 2 mm (figured immature left valve).

Type: Evidently lost; not in Finch collection in British Museum (Natural History). (Blackwelder, B. W., oral commun).

Type locality: Alleged to be Maryland, but Glenn thought it is Yorktown, Miocene.

The description is based on the illustrated incomplete immature left valve, recovered from the middle part of the Gatun formation. An internal mold of a larger right valve (incomplete length 21.7 mm, estimated restored length 24 mm, height 17 mm), from the same part of the Gatun, also is assigned to *Tellina aequistriata*. The closely spaced lamellae are impressed on parts of the mold; the extreme posterior ventral part is missing. An internal mold of a right valve from the Chagres sandstone that shows no sculpture is doubtfully identified as that species.

Gardner doubted the locality record for Dall's specimens from the Chipola formation, and Woodring doubted Dall's identification of an incomplete valve from Bowden, Jamaica. The identification is now regarded as satisfactory.

Occurrence: Middle part of Gatun formation (middle Miocene), eastern area, localities 139c, 147. Chagres sandstone (late Miocence or early Pliocene), locality 200 (identification doubtful). Chipola formation (early Miocene), Florida. Bowden formation (middle Miocene), Jamaica. Yorktown formation (early Pliocene, Virginia. Formations of middle Miocene to Pliocene age, southeastern United States. Living, southern Florida to Bahia, Brasil.

Subgenus Miratellina Woodring, n. subgen.

Type: *Tellina* (*Miratellina*) *anaxia* Woodring, n. sp. Gatun formation, Miocene.

Of medium size to large, thin-shelled, broadly subelliptical, height 70 to 75 percent of length. Almost equilateral or somewhat inequilateral, posterior end somewhat more extended than anterior. Left valve moderately convex; right valve of type species almost flat. Posterior end slightly bent. Anterior dorsal margin concave; anterior lateral margin broadly rounded; posterior dorsal margin slightly convex, or almost straight; posterior lateral margin less broadly rounded than anterior; ventral margin gently convex. Umbo sharply pointed, prosogyrate. Narrow carina on right valve near posterior end; similar carina present or absent on left valve. Sculpture of narrow, closely or widely spaced, concentric lamellae. Microscopic concentric threadlets between lamellae of left valve present or absent. Lamellae in form of open sigmoid curve on posterior slope and in corresponding position on left valve lacking carina; or lamellae practically disappearing on carinate left valve. Faint microscopic radial lineation on ventral part of valves. Interior unknown.

The subgenus *Miratellina* is distinguished by its thin shell, broadly subelliptical outline, and discrepant convexity of the valves, at least of the type species. It embraces two fossil species: the type species and *Tellina aequizonata* (Pilsbry and Olsson, 1941, p. 68, pl. 14, fig. 7), a Pliocene species from Ecuador, the right valve of which is unknown. Unfortunately the interior of both species is unknown.

When Olsson proposed *Lyratellina* (Olsson, 1961, p. 383; type (orthotype) : *Tellina lyra* Hanley, living, Baja California to northern Perú), he assigned *Tellina aequizonata* and *T. protolyra* (Anderson, 1929, p. 174, pl. 21, figs. 2, 3; Miocene, Colombia) to it. Boss (1966–1968, pt. 1, p. 260, 1966) treated *Lyratellina* as a synonym of *Merisca*, a treatment that has much in its favor. *T. protolyra* is regarded as a species of the subgenus *Merisca*. The type (the only known specimen) is available through the kindness of Dr. Barry Roth, of the California Academy of Sciences. It is articulated. Both valves lack a carina. The left valve is obliquely strongly convex, slightly more convex than the right. Despite its name, it is not closely related to *T. lyra*.

Tellina (Miratellina) anaxia Woodring, n. sp.

Plate 117, figures 26, 29, 30

The following description consists of features distinguishing *Tellina anaxia* from *T. aequizonata;* otherwise, features of *Miratellina* are applicable.

Of medium size, almost equilateral. Left valve moderately convex, right valve almost flat. Narrow carina on right valve near posterior end; similar carina absent on left valve. Concentric lamellae closely spaced, continuing to posterior margin on both valves. Microscopic concentric threadlets between lamellae of left valve.

Length 40.7 mm, height 28.5 mm, convexity (both valves) 8.6 mm (type).

Type (articulated specimen): USNM 647545.

Type locality: 136a (Stanford University 2611, north side of Transisthmian Highway, knoll about 30 m north of highway, 1.2 km northwest of Sabanita; lat 9°21′N., plus 1,100 feet (335 m), long 79°49′W., Panamá; same as USGS 16912), lower part of Gatun formation.

Tellina anaxia is distinguished from *T. aequizonata* chiefly by its smaller size (length 40.7 mm, as compared with 55 mm) and closely spaced concentric lamellae.

Occurrence: Lower part of Gatun formation (middle Miocene), locality 136a.

Subgenus Eurytellina Fischer

Fischer, Manuel de conchyliologie, p. 1147, 1887.

Type (monotype): *Tellina punicea* Born, living, Belize and Jamaica to Santa Catarina, Brasil.

Tellina (Eurytellina?) species

Plate 85, figure 2

Small, broadly subelliptical, height 73 percent of length, practically equilateral, right valve slightly more convex than left. Anterior end more broadly rounded than posterior. No trace of sculpture on internal mold. Interior unknown.

Length 20.5 mm, height 15 mm, convexity (both valves) 6.6 mm (figured specimen).

An internal mold of articulated valves from limestone of the Gatuncillo formation is doubtfully assigned to *Eurytellina*. In size and outline it is similar to *Tellina donacialis* Lamarck, as illustrated by Cossman and Pissarro (1904–1906, pl. 6, fig. 35–18), but is practically equilateral. According to the dentition, Lamarck's species from the middle and late Eocene of the Paris basin is not a *Eurytellina*, nor is it a species of *Moerella*, to which it was assigned by Cossmann and Pissarro.

Occurrence: Gatuncillo formation (late Eocene), locality 9.

Tellina (Eurytellina) alincia Woodring, n. sp.

Plate 90, figures 10, 11

Small, elongate-subelliptical, practically equilateral, slightly convex. Anterior margin more broadly rounded than posterior. Low faint carina near posterior end. Sculpture of faint concentric markings, changing to faint closely spaced threads on parts of both ends of shell, or consisting of closely spaced striae on most of shell. Interior unknown.

Length (incomplete) 15.5 mm (estimated restored length 16 mm), height (incomplete) 10 mm (estimated restored height 10.5 mm), convexity about 2.5 mm (type). Length 15.9 mm, height 10.3 mm, convexity about 1.5 mm (paratype).

Type (right valve): USNM 647547. Paratype (corroded right valve): USNM 135233.

Type locality: 42 (USGS 17692, northeast coast of Trinidad Island, sandy siltstone, basal 3 m of exposed section, Canal Zone), marine rocks of late Eocene age. Paratype locality: 40a (USGS 2683, Vamos Vamos, Canal Zone, a locality off Palenquilla Point submerged by Gatun Lake), marine rocks of late Eocene age.

On external features five valves of a small *Tellina* from the marine rocks of late Eocene age are assigned to *Eurytellina*. So far as the external features go, these fossils qualify as a small predecessor of *T. punicea*, the next species under consideration. In addition to being smaller than *T. punicea*, the type of *T. alincia*—the only valve on which most of the shell is preserved—has a stronger posterior carina. The carina of *T. punicea* is greatly subdued or is indicated by a change in the alinement of the sculpture. A corroded right valve (locality 40d) shows sculpture like that of *T. punicea*.

Occurrence: Marine rocks of late Eocene age, localities 40a, 40d, 40e, 42.

Tellina (Eurytellina) punicea Born

Plate 92, figure 5; plate 115, figures 4, 5, 8, 9

Tellina punicea Born, Index rerum naturalium Musei Caesarei Vindobonensis, pt. 1, p. 22, 1778 (living, locality not specified). Born, Testacea Musei Caesarei Vindobonensis, p. 33, pl. 2, fig. 8, 1780 (living, locality not specified).

Tellina (*Eurytellina*) *punicea* Born, Weisbord, Bull. Am. Paleontology, v. 45, no. 204, p. 335, pl. 48, figs. 14, 15, pl. 49, figs. 1, 2, 1964 (Pliocene, Venezuela). Boss, Johnsonia, v. 4, no. 46, p. 274, pl. 143, fig. 2, pl. 144, fig. 2, pl. 150, fig. 3, 1968 (living, Belize and Jamaica to Santa Catarina, Brasil).

Eurytellina punicea (Born)?, Jung, Bull. Am. Paleontology, v. 55, no. 247, p. 385, pl. 32, figs. 1–5, 1969 (Pliocene, Trinidad).

Tellina dariena Conrad, Appendix to the preliminary geological report of William P. Blake: U. S. 33rd Cong., 1st Sess., House Doc. 129, p. 18, 1855; reprint Dall, U. S. Geol. Survey Prof. Paper 59, p. 170, 1909 (Miocene, Canal Zone). Conrad, *in* Blake, U. S. Pacific R. R. Explor., v. 5, app., art. 2, p. 328, pl. 6, fig. 53, 1857 (Miocene, Canal Zone). Gabb, Acad. Nat. Sci. Philadelphia Jour., 2d ser., v. 8, p. 343, pl. 44, fig. 13, 1881 (Oligocene(?), Costa Rica; Miocene, Panamá). Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 63, p. 368, 1911 (Miocene, Canal Zone, Conrad's record). Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 252 (assigned to section *Eurytellina*), pl. 26, fig. 3, 1922 (Miocene, Panamá). Anderson, California Acad. Sci. Proc., 4th ser., v. 18, no. 4, p. 172, 1929 (Miocene, Colombia).

Tellina Rowlandi Toula, K. k. Geol. Reichsanstalt Jahrb., v. 58, p. 728, pl. 28, fig. 11, 1909 (Miocene, Canal Zone).

Tellina rowlandi Toula, Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 63, p. 368, 1911 (Miocene, Canal Zone, Toula's record).

Tellina cf. *punicea* Born, Toula, K. k. Geol. Reichsanstalt Jahrb., v. 61, p. 495, pl. 31, figs. 6a, 6b, 1911 (Miocene, Canal Zone).

Small to medium size, elongate-subelliptical, practically equilateral, or slightly inequilateral, anterior end slightly more extended than posterior. Slightly convex. Anterior margin more broadly rounded than posterior. Low faint carina present or absent near posterior end. Sculpture of shallow, closely spaced concentric striae, generally most distinct near ends of valve, partly or entirely obliterated on worn valves, and obliterated in umbonal area. Hinge of right valve: wedge-shaped anterior and bifid posterior cardinal teeth; strong anterior lateral tooth close to anterior cardinal, strong posterior lateral tooth far from posterior cardinal. Hinge of left valve: thin bifid anterior and very thin posterior cardinal teeth; weak anterior lateral tooth close to anterior cardinal, weak posterior lateral tooth far from posterior cardinal. Pallial sinus extending to anterior muscle scar.

Length (incomplete) 22.1 mm (estimated restored length 24 mm), height 13 mm, convexity 3 mm (figured right valve from Gatun formation). Length 21.2 mm, height 13.6 mm, convexity 2.8 mm (figured left valve from the Gatun). Length (incomplete) 37 mm (estimated restored length 38 mm), height 20.5 mm, convexity about 4 mm (largest specimen from the Gatun). Length 36 mm, height 21.8 mm, convexity about 3 mm (figured left valve from Caimito formation).

Type: Presumably at Natural History Museum, Vienna.

Type locality: Caribbean region, restricted to Guayaguayare Beach, Trinidad (Boss, 1966–1968, pt. 2, p. 274, 1968). (Restriction of type localities has no standing under the International Code of Zoological Nomenclature.)

Tellina punicea is widespread in the Gatun formation but is nowhere abundant. The largest of 60 specimens are incomplete or otherwise poorly preserved. All from the lower part of the formation are small. Very small and minute valves (length 3.5 to 10 mm) are not unusual; in fact, four lots in the three parts of the formation consist entirely of such immature specimens. Five valves from the Caimito formation of Barro Colorado Island, one of which is illustrated (pl. 92, fig. 5), also are identified as *T. punicea*. The largest from the Caimito are of about the same size as the largest from the Gatun.

The type of Conrad's *T. dariena* is lost. His illustration is considered to be a reasonably satisfactory representation of *T. punicea*. Gabb identified it also in the Oligocene(?) fossils he collected on Oronli Creek in southeastern Costa Rica. (For the age of the fossiliferous black shale on Oronli Creek see p. 100 of P 306–A.)

T. punicea has an exceptionally long range: Oligocene to the present time.

Occurrence: Caimito formation (late Oligocene), localities 54h, 54k, 54 m. Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, localities 135, 136, 136a, 138, 138a, 138c, 138d. Middle part, eastern area, localities 139b, 139g, 144c, 147b, 153a, 156; western area. localities 160, 161d, 162a, 169. Upper part, eastern area, localities 172, 173a, 175, 176, 177, 177a, 177b, 177d. Deposits of Oligocene(?) age on Oronli Creek, Limón Province, Costa Rica (Gabb's record). Miocene deposits, Colombia (Anderson's record). Limónes formation (late Miocene), Bocas del Toro area, Panamá (Olsson's record). Mare formation (early Pliocene), Venezuela. Courbaril member of Morne l'Enfer formation (early Pliocene), Trinidad. Living, Belize and Jamaica to Santa Catarina, Brasil.

Tellina (Eurytellina) nitens C. B. Adams

Plate 117, figures 16, 17

Tellina nitens C. B. Adams, Boston Soc. Nat. History Proc., v. 2, p. 10, 1845 (living, Jamaica). Clench and Turner, Harvard Univ., Mus. Comp. Zoology, Dept. Mollusks, Occasional Papers on Mollusks, v. 1, no. 15, p. 317, pl. 44, figs. 3, 4, 1950 (living, Jamaica).

Tellina (*Eurytellina*) *nitens* C. B. Adams, Boss, Johnsonia, v. 4, no. 46, p. 288, pl. 147, figs. 3, 4, pl. 148, fig. 1, pl. 149, fig. 4, pl. 150, fig. 1, 1968 (living, North Carolina to Tobago).

Tellina (*Eurytellina*) *roburina* Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 5, p. 1024, pl. 47, fig. 9, 1900 (Miocene, Florida). Gardner, U.S. Geol. Survey Prof. Paper 142-E, p. 194, pl. 29, fig. 15, 1928 (Miocene, Florida).

Of medium size, thin-shelled, elongate-subelliptical, slightly inequilateral, anterior end slightly more extended than posterior. Slightly convex. Anterior dorsal margin slightly convex; anterior lateral margin rounded. Posterior margin slightly concave adjoining pointed umbo, otherwise straight, narrowly rounded at ventral end. Ventral margin slightly convex. Sculpture of shallow, closely spaced concentric striae, effaced in umbonal area, replaced on posterior slope of right valve by widely spaced concentric lamellae. Hinge of right valve: wedge-shaped anterior and bifid posterior cardinal teeth; strong anterior lateral tooth fairly close to anterior cardinal, short, strong posterior lateral tooth far from posterior cardinal. Hinge of left valve: bifid anterior and very thin posterior cardinal teeth; weak anterior lateral tooth some distance from anterior cardinal, weak posterior lateral tooth far from posterior cardinal. Pallial sinus indistinct.

Length 23 mm, height 12.5 mm, convexity about 4 mm (larger figured right valve). Length 30.2 mm, height about 18 mm (shattered left valve, only valve of medium size).

Type: Mus. Comp. Zoology 155606.

Type locality: Jamaica, living.

The outline, discrepant sculpture of right valves, and hinge are the basis for the identification of seven right valves and one left, from the middle part of the Gatun formation, as *T. nitens*.

T. roburina, which is abundant in the Oak Grove sand member of the Shoal River formation of Florida, reaches a size as large as living shells. *T. paraguanensis* (H. K. Hodson, *in* Hodson and Hodson, 1931a, p. 12, pl. 5, figs. 5, 6, 11; Jung, 1965, p. 472, pl. 61, figs. 2, 5, 6; middle Miocene, Venezuela) is closely related to *T. nitens* but is somewhat less elongate.

Occurrence: Middle part of Gatun formation (middle Miocene), eastern area, localities 150, 159d. Oak Grove sand member of Shoal River formation (middle Miocene), Florida. Living, North Carolina to Rio de Janeiro, Brasil.

Tellina (Eurytellina) angulosa costaricana Olsson

Plate 117, figures 24, 27

Tellina costaricana Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 251 (assigned to section *Eurytellina*), pl. 26, figs. 6, 9, 1922 (Miocene, Costa Rica).

Of medium size, trigonal-ovate, height 60 to 65 percent of length, equilateral or practically so, slightly convex. Dorsal margins straight or practically so. Anterior end broadly rounded, posterior end subtruncated at base. Ventral margin very slightly convex. Subdued, very narrow carina near posterior end, or carina replaced by subdued angulation, along which alinement of sculpture changes. Slight depression near anterior end of largest right valve. Sculpture of deep, regularly and closely spaced concentric striae. Right hinge: wedge-shaped anterior and bifid posterior cardinal teeth; strong anterior lateral tooth close to anterior cardinal, strong short posterior lateral tooth far from posterior cardinal. Hinge of left valve inaccessible. Pallial sinus indistinct.

Length 45 mm, height 28.6 mm, convexity 5 mm (figured right valve, largest specimen).

Type: Lectotype, herewith designated, left valve illustrated by Olsson as pl. 26, fig. 6, Paleontological Research Inst. 21235.

Type locality: Río Banano, Limón Province, Costa Rica.

A strongly sculptured *Tellina*, identified as *T. angulosa costaricana*, occurs in the lower and middle parts of the Gatun formation: a total of 20 specimens, three of which are articulated, and many of which are immature. The illustrated right valve, the largest of all, has the most distinct carina and is the only one that shows a slight anterior depression. Unfortunately, it was broken during handling.

A considerable number of American fossil and living species of *Eurytellina*, more or less closely allied to the common *T. alternata* Say, now ranging from North Carolina to the eastern Gulf of Mexico, have been described. *T. costaricana* is perhaps most closely related to the Caribbean *T. angulosa* Gmelin (Boss, 1966–1968, pt. 2, p. 281, pl. 143, fig. 1, pl. 144, fig. 3, pl. 148, fig. 2, 1968). The sculpture of the fossils from the Gatun is stronger and more regular than that of the living nominate subspecies; in fact, it suggests the sculpture of *T. tayloriana* Sowerby (Olsson and Harbison, 1953, p. 124, pl. 14 figs. 1, 1a, 1b), at present a western Gulf of Mexico species. In addition, no trace of faint radial lineation is apparent on the fossils.

Two of the three forms of *Eurytellina* in the Gatun formation are still living in the Caribbean region, and the third is classified as an apparently extinct subspecies of a species also living there.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, localities 138, 138c, 138d. Middle part, eastern area, localities 139c, 144a, 144c, 147b, 159d; western area, locality 161a. Middle Miocene deposits, Limón Province, Costa Rica.

Tellina (Eurytellina) ophiaca Woodring, n. sp.

Plate 92, figure 2

Small, trigonal-ovate, height 55 to 65 percent of length (generally 60 to 65 percent). Generally slightly inequilateral, anterior end slightly more extended than posterior; exceptionally equilateral, or practically equilateral. Slightly convex. Anterior dorsal margin barely convex; posterior dorsal margin generally barely concave. Anterior lateral margin broadly rounded; posterior lateral margin narrowly rounded. Posterior end somewhat flattened but not carinate. Sculpture revealed by only two specimens: shallow, closely spaced concentric striae. Interior unknown.

Length 27 mm, height 17.3 mm ,convexity (both valves) 9.2 mm (type).

Type (right valve of internal mold of articulated specimen): USNM 647575.

Type locality: 112a (USGS 16927, west side of Gaillard Cut, Canal station 1922, about 30 m southwest of edge of Canal; top of bed 13 of section on page 35 of P 306–A; Canal Zone). Culebra formation.

Tellina ophiaca is abundant in the transition zone between the Culebra and Cucaracha formations on both sides of the Culebra Reach of the canal, and occurs also in the La Boca formation and doubtfully in the Cucaracha. All except one of the 134 specimens from the Culebra were cracked out of calcareous layers and calcareous concretions in bed 13 of the section on the west side of the canal, reproduced on page 35 of P 306–A, or are in a collection of fossils weathered out of what is doubtless the same bed on the east side. All these specimens, ranging in length from 9.5 to 27 mm, are internal molds of articulated valves. On the few, like the type, that retain part of the shell, the original aragonite is recrystallized to calcite, on which the sculpture is obliterated. On the type (the largest of these fossils), however, the weak sculpture is impressed on the ventral part of the mold. The exception is a right valve, collected on the west side of the canal in a shallow crater formed by a small test explosion (locality 111b). Some patches of corroded shell show the sculpture.

Though the interior is unknown, this species is assigned to *Eurytellina*, chiefly on the basis of the similarity to *T. tumbezensis* (Olsson, 1961, p. 403, pl. 68, fig. 5, pl. 69, fig. 8), which is regarded as a species of that subgenus. *T. tumbezensis* lives on mudflats at the mouth of Río Tumbes in northern Perú. It is more inequilateral than *T. ophiaca*. The fossils from the Culebra are in a mixed marine and brackish-water association and perhaps tolerated water of low salinity, as does the living Peruvian species. No record of a fossil or living west Atlantic *Tellina* that has such tolerance has been found.

MacDonald and Vaughan collected 14 internal molds of isolated valves from bed 11 of MacDonald's section of the La Boca formation in the tower N area on the west side of the Las Cascadas Reach of the canal (MacDonald, 1919, p. 537–539; for location of tower N area see p. 587 of present account). These fossils are in a marine association. Both underlying and overlying beds contain *T. vetula*, the next described species.

Two of the internal molds from the Culebra at localities 110 and 112a, which are exceptionally elongate (height 51 and 56 percent of length, respectively), are doubtfully identified as *T. ophiaca*. So are three crushed, poorly preserved specimens from black carbonaceous clay in the lower part of the Cucaracha formation.

Occurrence: Culebra formation (early Miocene), localities 110, 111a, 111b, 112, 112a. Cucaracha formation (early Miocene), locality 122 (identification doubtful). La Boca formation (early Miocene), Gaillard Cut area, locality 99b.

Tellina (Eurytellina) vetula Brown and Pilsbry

Plate 99, figures 4, 5

Tellina (Eurytellina) vetula Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 64, p. 517, pl. 26, fig. 6, 1913 (Miocene, Canal Zone).

Of medium size, trigonal-ovate to elongate-ovate, height 53 to 67 percent of length, slightly to moderately inequilateral, anterior end more extended than posterior. Moderately convex. Anterior dorsal margin barely convex; posterior dorsal margin barely concave or practically straight. Anterior lateral margin broadly rounded; posterior lateral margin narrowly rounded or subtruncated. Posterior end somewhat flattened, or obscurely carinate, or carinate; carina low and narrow. Sculpture of closely spaced, low concentric lamellae, obscure or absent on many specimens, especially on internal molds. Hinge and pallial sinus unknown.

Length 40.5 mm, height 25 mm, convexity 8.7 mm (larger figured valve, largest specimen).

Type: Formerly at Acad. Nat. Sci. Philadelphia, now lost or misplaced.

Type locality: "*Pecten* bed" near tower N [Panama Canal, west side of Las Cascadas Reach], Canal Zone, La Boca formation.

The collections from the La Boca formation contain 42 specimens of *Tellina vetula*, ranging in length from about 11 to 40.5 mm. Though many are internal molds, none is articulated. The outline and the tendency to develop a low narrow carina are variable. The sculpture is not apparent on the worn largest valve (pl. 99, fig. 5).

T. vetula is closely related to *T. ophiaca*, the preceding species, but is larger, more strongly sculptured, and shows a tendency to develop a low narrow carina. Both species occur in the La Boca formation, but not at the same locality. *T. vetula* is closely related also to *T. trinitatis* (Tomlin) (Boss, 1966–68, pt. 2, p. 279, pl. 145, pl. 149, fig. 5, 1968), the type of which was dredged in Colón harbor (Limón Bay) at a depth of 5 fathoms. Its sculpture is weaker than that of *T. vetula*, and it shows no tendency to develop a carina.

Occurrence: La Boca formation (early Miocene), Gaillard Cut area, localities 99c, 99d, 99e, 99f, 99g, 99h, 100, 101i, 114, 115a, 115b, 116a; Las Cruces area, locality 94; Summit area, locality 127.

Subgenus Angulus Megerle von Muhlfeld

Megerle von Mühlfeld, Gesell. Naturforschender Freunde Berlin Magazin, v. 5, p. 47, 1811.

Type (logotype, Gray Zool. Soc. London, Proc., p. 186, 1847): *Tel*[*lina*] *lanceolata* [Gmelin], living western Pacific Ocean.

Tellina (Angulus?) species

Plate 90, figure 1

Very small, elongate-subelliptical, height 50 to 62 percent of length. Inequilateral, anterior end more extended than posterior. Moderately convex. Anterior dorsal margin almost straight; posterior dorsal margin slightly convex. Anterior lateral margin more broadly rounded than posterior. Posterior end somewhat pinched. Remnants of weak concentric sculpture. Interior unknown.

Length 5.8 mm, height 3.6 mm, convexity about 1 mm (figured left valve).

A second very small *Tellina* from the marine rocks of late Eocene age is represented by three molds, which retain some inner shell material. The outline suggests the subgenus *Angulus*.

Occurrence: Marine rocks of late Eocene age, locality 40d.

Tellina (Angulus) cf. T. (A.) umbra Dall

Plate 123, figure 6

Small, elongate-subelliptical, height 60 to 65 percent of length. Inequilateral, anterior end more extended than posterior. Moderately convex. Anterior dorsal margin slightly convex; posterior dorsal margin slightly concave near umbo; otherwise slightly convex. Anterior lateral margin more broadly rounded than posterior. Valve subangulated near posterior end. Traces of weak concentric sculpture. Interior unknown.

Length 12.2 mm, height 7.5 mm, convexity about 1.5 mm (figured right valve).

Nine more or less corroded valves from the Chagres sandstone are identified as *Tellina* cf. *T. umbra* (Dall, 1890–1903, pt. 5, p. 1033, pl. 46, fig. 13, 1900). They are less elongate than that species, the type of which occurs in the Duplin formation (of former usage) of North Carolina, *T. umbra* has been identified in the middle Miocene deposits of southeastern Costa Rica (Olsson, 1922, p. 253, pl. 26, figs. 12, 15).

Occurrence: Chagres sandstone (late Miocene or early Pliocene), localities 206, 206b.

Genus Tellidora Henry and Arthur Adams

Henry and Arthur Adams, The genera of Recent Mollusca, v. 2, p. 401, 1856.

Type (logotype, Stoliczka, India Geol. Survey Mem., Palaeontologia Indica, Cretaceous fauna of southern India, v. 3, p. 116, 1870): *Tellina burneti* Broderip and Sowerby, living, Baja California to Ecuador.

Tellidora cristata (Recluz)

Lucina cristata Récluz, Revue Zool. Soc. Cuvierienne, v. 5, p. 270, 1842 (living, Campeche Banks). Récluz, Magasin Zool., 2d ser., 5th year, Mollusques, 2 p., pl. 60, figs. 1–5, 1843 (living, Campeche Banks).

Tellidora cristata Récluz, Dall, U. S. Nat'l. Mus. Proc., v. 21, p. 298, 1900 (Pliocene, living, North Carolina to Trinidad). Dall, Wagner Free Inst. Sci. Philadelphia Trans., v. 3, pt. 5, p. 1037, 1900 (Pliocene and Pleistocene, southeastern United States, living, North Carolina to Trinidad). Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 254, pl. 26, figs. 1, 2, 1922 (Miocene, Costa Rica). Boss, Johnsonia, v. 4, no. 46, p. 339, pl. 163, 1968 (living, North Carolina to Yucatan).

Tellidora lunulata Holmes, Post-Pleiocene fossils of South Carolina, p. 47, pl. 9, figs. 6, 6a, 6b, 7, 7a–d, 1860 (Pleistocene, South Carolina). Olsson and Harbison, Acad. Nat. Sci. Philadelphia Mon. 8, p. 131, 1953 (Pliocene, Florida).

Tellidora sp., Jung. Bull. Am. Paleontology, v. 55, no. 247, p. 389, 1969 (Miocene, Trinidad).

Of medium size, trigonal-ovate, moderately thin-shelled, height almost equal to length. Equilateral, left valve slightly convex. Anterior dorsal margin slightly concave; posterior dorsal margin slightly convex. Ventral margin broadly rounded, slightly insinuated in front of posterior slope. Umbo high, sharply pointed. Posterior slope very narrow, depressed. Sculpture of coarse, widely spaced concentric undulations, subdued or suppressed near dorsal margins, but some fociaceous at margins. Hinge of left valve: narrow, bifid anterior and very narrow posterior cardinal teeth; very weak anterior and posterior lateral teeth far from cardinals. Pallial sinus indistinct. Hinge of right valve unknown.

Length 39.7 mm, height 33.3 mm, convexity 3.6 mm (figured left valve). Length 41.8 mm, height 32.1, convexity about 4 mm (largest specimen, left valve).

Type: Presumably at Paris.

Type locality: Campeche Banks, Gulf of Mexico, living.

Five specimens of *Tellidora cristata* were found in the middle part of the Gatun formation. The illustrated left valve and an immature right are the only ones on which all of the shell is preserved. That illustrated and the slightly larger largest valve are larger than any living specimens in USNM collections and also larger than those available to Boss. Olsson commented on the large size of Costa Rican shells, and Olsson and Harbison, on those of Pliocene age. The fossils from the Gatun are also more strongly sculptured than living shells.

T. cristata, like many living Caribbean species, the age range of which extends back to Miocene, has a closely related counterpart in the eastern Pacific Ocean: *T. burneti*, the type of the genus and the only other known species. As pointed out by Dall many years ago, the right valve of *T. cristata* is slightly more convex than the left, whereas the valve convexity of *T. burneti* is the reverse. According to USNM collections, the posterior insinuation of the ventral margin as wide and deep as that of the specimens of *T. burneti* illustrated by Olsson (1961, p. 381, pl. 69, figs. 1, 1a, 1b) is exceptional.

The geographic range of *T. cristata* has been restricted toward the north since Miocene time.

Occurrence: Middle part of Gatun formation (middle Miocene), eastern area, locality 159d; western area, localities 161, 161c. Middle Miocene deposits, Limón Province, Costa Rica. Melajo clay member of Springvale formation (late Miocene), Trinidad. Deposits of late Miocene age, peninsular Florida. Caloosahatchee formation (Pliocene), Florida. Living, North Carolina to Yucatán.

Genus Strigilla Turton

Turton, Conchylia Insularum Britannicarum, Dithyra, p. 117, 1822.

Type (logotype, Gray, Zool. Soc. London Proc., p. 186, 1847): *Tellina carnaria* [Linné], living, Florida to Mar del Plata, Argentina.

Subgenus Strigilla s.s.

Strigilla (Strigilla) protera Woodring, n. sp.

Plate 90, figures 12, 14

Very small, triangular-ovate, height 78 to 81 percent of length. Inequilateral, posterior end more extended than anterior. Convexity moderately strong. Anterior end broadly rounded, posterior end narrowly rounded. Scissula on posterior slope forming acute angle pointing ventrally; scissula obscure on anterior slope. Interior unknown.

Length (incomplete) 6 mm (estimated restored length 6.5 mm), height 5.3 mm, convexity about 2 mm (type). Length 9 mm, height 8 mm, convexity about 2.5 mm (largest specimen).

Type (right valve): USNM 647583; paratype (right valve) USNM 647584.

Type and paratype locality: 40d (USGS 6028a, Vamos Vamos, lower bed, Canal Zone), marine rocks of late Eocene age.

The marine rocks of late Eocene age yielded 64 specimens of *Strigilla protera*. Almost half of the 32 more or less corroded valves from the type locality (the largest lot) show at least some sculpture, but only a few show the scissula on the posterior slope. Dall had labelled this lot *Strigilla* when it was received in 1911.

Strigilla protera is the earliest known species of the genus in the Caribbean region. Not only in that area but also in southeastern United States, no pre-Miocene occurrences are on record. Gardner (1945, p. 108), however, recorded *Strigilla*? sp. from strata in northeastern México assigned to the Laredo formation (middle Eocene). Her poorly preserved right valve (length 6.8 mm) probably represents *Strigilla* s.s.

Occurrence: Marine member of Bohio(?) formation (late Eocene), localities 40a, 40d, 40e, 41, 41a, 41b.

Strigilla (Strigilla) aff. S. carnaria (Linne)

Small, triangular-ovate, height 84 or 85 percent of length. Inequilateral, posterior end more extended than anterior. Strongly convex. Anterior end broadly rounded, posterior end less broadly rounded. Scissula on posterior slope forming acute angle pointing ventrally; scissula gently bowed upward on posterior part of anterior slope and downward between that arch and shell margin. Interior unknown.

Length 10.5 mm, height 8.9 mm, convexity about 3 mm (largest specimen).

The description is based on three valves from the La Boca formation. They are too fragile for safe handling; in fact, the best preserved one fell apart. This small species probably is a predecessor of *Strigilla carnaria*, the next species under consideration. It is half as large as that species, and its ratio of height to length is somewhat lower.

Two other lots from the La Boca show no scissula and are listed as *Strigilla* sp.

Occurrence: La Boca formation (early Miocene), Gaillard Cut area, locality 116a.

Strigilla (Strigilla) carnaria (Linne)

Plate 117, figures 21, 25

Tellina carnaria Linné, Systema naturae, 10th ed., p. 676, 1758 (living, locality not specified in shallow seas (Oceani brevibus)).

Strigilla carnaria Linnaeus, Weisbord, Bull. Am. Paleontology, v. 45, no. 204, p. 349, pl. 50, figs. 9–12, pl. 51, figs. 1–6, 1964. (Pliocene, Pleistocene, living, Venezuela; additional citations).

Strigilla (*Strigilla*) *carnaria* (Linné)?, Jung, Bull. Am. Paleontology, v. 55, no. 247, p. 389, pl. 33, figs. 10, 11 1969 (Pliocene, Trinidad). Boss, Johnsonia, v. 4, no. 47, p. 349, pl. 166, figs. 3, 4, pl. 167, figs. 1, 2, pl. 168, fig. 1, 1969 (living, Florida and Bahamas to Mar del Plata, Argentina).

Similar to preceding species, but of medium size, height 90 or 91 percent of length. Hinge of right valve: narrow anterior and bifid, oblique posterior cardinal teeth; strong anterior lateral tooth adjoining anterior cardinal, strong posterior lateral tooth adjoining nymph. Hinge of left valve not preserved. Pallial sinus indistinct.

Length 16.6 mm, height 15 mm, convexity 4.5 mm (figured right valve). Length 16.3 mm, height 14.8 mm, convexity 3.7 mm (figured left valve).

Type: Five syntypes, Museum of Linnean Society of London (see Boss, 1969, p. 350).

Type locality: West Indies, restricted by Boss to Barbados.

A right and a left valve, and seven immature valves, all from the middle part of the Gatun formation, are identified as *Strigilla carnaria*. The presumably mature valves are smaller than living specimens, which reach a length of 25 to 28 mm. Inasmuch as the pallial sinus is unknown, these fossils might represent *S. pseudocarnaria* (Boss, 1969, p. 352, pl. 166, figs. 1, 2), also living in the Caribbean region. The two species have been confused frequently.

Occurrence: Middle part of Gatun formation (middle Miocene), eastern area, localities 155c, 156; western area, localities 161c, 170, 170a. Courbaril member of Morne l'Enfer formation and Matura formation (early Pliocene), Trinidad. Living, Florida and Bahamas to Mar del Plata, Argentina.

Subfamily MACOMINAE

Genus Psammacoma Dall

Dall, U. S. Natl. Mus. Proc., v. 23, p. 292, 1900.

Type (orthotype): *Macoma candida* (Lamarck) (*Psammotaea candida* Lamarck), living, western Pacific Ocean.

Psammacoma diphas Woodring, n. sp.

Plate 92, figures 4, 8; plate 100, figure 8

Of medium size, elongate-subelliptical; exceptionally triangular-ovate. Height 55 to 63 percent of length. Inequilateral, anterior end more extended than posterior; exceptionally practically equilateral. Right valve slightly more convex than left. Anterior dorsal margin slightly convex; posterior dorsal margin very slightly to distinctly concave; exceptionally practically straight. Ventral margin slightly convex. Anterior end broadly rounded; posterior end more narrowly rounded. Posterior slope generally somewhat pinched. Sculpture of irregularly spaced growth lines, emphasized here and there, especially on posterior slope. Interior unknown.

Length (incomplete) 47.7 mm (estimated restored length 51 mm), height 29.1 mm, convexity (both valves) 14.5 mm (type, largest specimen). Length 42.9 mm, height 25 mm, convexity (both valves) 8.5 mm (paratype). Length 39.5 mm, height 20.3 mm, convexity about 3 mm (figured left valve from La Boca formation)

Type (articulated specimen): USNM 647587; paratype (articulated specimen) USNM 647588.

Type locality: 111b (USGS 16888, west side of Gaillard Cut, Canal station 1916, from dirty sandstone brought to surface by test explosion, evidently from base of bed 13 of section on p. 35 of P. 306–A, Canal Zone), Culebra formation. Paratype locality: 110 (USGS 16886 (east side of Gaillard Cut, Canal station 1916, about 60 m northeast of edge of canal and about 100 m northwest of northwest edge of Culebra Extension slide, Canal Zone), Culebra formation.

Psammacoma diphas, like *Tellina ophiaca*, is especially characteristic of the transition zone between the Culebra and Cucaracha formations on both sides of the canal in the Culebra Reach. It is rare in the La Boca formation. All except one of the 33 available specimens from the Culebra are basically internal molds of articulated valves, which retain more or less shell material, recrystallized to calcite. They show a considerable range of variation in outline, but an immature triangular-ovate, practically equilateral specimen (length 20.6 mm, height 14 mm, locality 111a) is the only one that is really exceptional. The type is by far the largest; the paratype is an example of the usual mature size. Four specimens, two of which are immature, were found in the La Boca formation.

P. diphas is smaller and generally more inequilateral than *P. gatunensis*, the following species. The posterior end is generally more attenuated than that of *P. tageliformis* (Dall) (Warmke and Abbott, 1961, p. 198, pl. 41, fig. 1), which ranges from the Gulf of Mexico and Florida to São Paulo, Brasil.

Occurrence: Culebra formation (early Miocene), localities 106, 110, 111a, 111b, 112, 112a. La Boca formation (early Miocene), Gaillard Cut area, localities 100, 101i, 116a.

Psammacoma gatunensis (Toula)

Plate 115, figures 10, 14, 16

Macoma (Tellina) gatunensis Toula, K. k. Geol. Reichsanstalt Jahrb., v. 58, p. 729, pl. 28, fig. 10, text-fig. 10, 1909 (Miocene, Canal Zone; *Tellina (Macoma) gatunensis* in explanation of plate).

Tellina gatunensis (Toula), Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 63, p. 368, 1911 (Miocene, Canal Zone, Toula's record).

Macoma gatunensis Toula, Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 257 (assigned to subgenus *Psammacoma*), pl. 26, fig. 13, 1922 (Miocene, Costa Rica).

Macoma (Psammacoma) gatunensis Toula, Hodson and Hodson, Bull. Am. Paleontology, v. 16, no. 59, p. 16 (in discussion), pl. 6, fig. 2, 1931 (Miocene, Canal Zone).

Not *Tellina gatunensis* (Toula), Anderson, California Acad. Sci., Proc., 4th ser., v. 18, no. 4, p. 173, 1929 (Miocene, Colombia).

Tellina aequiterminata Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 64, p. 517, pl. 26, fig. 5, 1913 (Miocene, Canal Zone).

Tellina (Eurytellina) aequiterminata Brown and Pilsbry, Anderson, California Acad. Sci. Proc., 4th ser., v. 18, no. 4, p. 173, pl. 23, fig. 4, 1929 (Miocene, Colombia).

Macoma panamensis canalis Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 257, pl. 26, fig. 11, 1922 (Miocene, Canal Zone).

Macoma (Psammacoma) falconensis H. K. Hodson, *in* Hodson and Hodson, Bull. Am. Paleontology, v. 16, no. 59, p. 16, pl. 6, figs. 1, 6, 7 (Miocene, Venezuela).

Psammacoma? cf. *falconensis* H. K. Hodson, Jung, Bull. Am. Paleontology, v. 49, no. 223 p. 473, pl. 61, figs. 3, 7, 1965 (Miocene, Venezuela).

Large, elongate-subelliptical, height 51 to 60 percent of length (generally 54 or 55 percent). Small valves thin-shelled. Inequilateral, anterior end generally more extended than posterior: degree of inequilaterality variable, ranging from very inequilateral to almost equilateral; exceptionally posterior end slightly more extended than anterior. Left valve slightly more convex than right. Anterior dorsal margin slightly convex; posterior dorsal margin slightly concave to practically straight. Ventral margin slightly convex. Anterior end broadly rounded; posterior end more narrowly rounded, or subtruncated. Posterior slope flattened, or slightly depressed. Sculpture of generally irregularly spaced growth lines, emphasized here and there, especially on posterior slope, where they are regularly and closely spaced. Hinge of right valve: fairly wide anterior and narrow bifid posterior cardinal teeth. Hinge of left valve: bifid anterior and narrow low posterior cardinal teeth. Pallial sinus indistinct or inaccessible.

Length 57.5 mm, height 31.2 mm, convexity about 5.5 mm (figured right valve). Length 63.2 mm, height 35 mm, convexity (both valves) 11.5 mm (lagrest specimen).

Type: Paläontologisches Inst. Univ. Wien.

Type locality: Presumably Gatun Locks excavation, Canal Zone, middle part of Gatun formation.

Psammacoma gatunensis is widespread in the Gatun formation—a total of 72 specimens having a length range of 12.3 to 63.2 mm. Only a few of these fossils are internal molds, but many are incomplete or corroded shells. Much of the range of variation is shown by Toula's three illustrations. The left valve in the lower part of his text figure is an example of the prevailing form. Many specimens, however, are similar to the right valve in the upper part of that illustration. A very inequilateral specimen from the upper part of the Gatun (pl. 115, fig. 16) is comparable with that shown on his plate 28, figure 10. A further item of variability is shown by an incomplete right valve, the posterior end of which is slightly longer than the anterior (length 62 mm, locality 166). Costa Rican, Darién, and Venezuelan specimens are not as large as those from the lower and middle parts of the Gatun. In view of the variability of Canal Zone representatives, *P. falconensis* is regarded as a synonym of *P. gatunensis*.

With the exception of a left valve (locality 176a, estimated restored length 47 mm), the 16 specimens from the upper part of the Gatun have a maximum length of 40.5 mm. One of the relatively small shells from that part (length 30.5 mm) was named *Macoma panamensis canalis* by Olsson. Some lots from the middle part duplicate those from the upper part in size and thin shell.

P. gatunensis is closely related to *P. lamproleuca* (Pilsbry and Lowe) (Olsson, 1961, p. 414, pl. 68, fig. 12, pl. 74, figs. 3–3b), which ranges from the Gulf of California to northern Perú and occurs in the Pliocene of Ecuador (Pilsbry and Olsson, 1941, p. 69). According to Olsson, that species reaches a length of 96.2 mm. The posterior dorsal margin of no available specimen is even slightly concave. *P. diphas*, *P. gatunensis*, and *P. lamproleuca* form a lineage graded in increasing size with decreasing age.

Two internal molds of moderate size from the lower member of the Alhajuela formation, an incomplete internal mold from the Toro limestone member of the Chagres sandstone, and a small specimen from the Chagres proper are listed as *Psammacoma* sp.

Occurrence: Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, localities 136a, 138a, 138c. Middle part, eastern area, localities 139c, 139g, 140, 143a, 144a, 144c, 147b, 147e, 147f, 147g, 147h, 153, 155, 155b, 155c, 157; western area, localities 160, 161, 161c, 166, 170a. Upper part, eastern area, localities 172, 173a, 175, 176, 176a, 177, 177b, 177c, 177d, 177e. Middle Miocene deposits, Limón Province, Costa Rica. Middle Miocene deposits, Darién Province, Panamá (USGS 8477). Middle Miocene deposits, Bolívar Dept., Colombia. Urumaco formation (middle or late Miocene), Falcón, Venezuela.

Psammacoma talaor Woodring, n. sp.

Plate 101, figure 2

Large, somewhat trigonal-ovate, height 62 percent of length. Slightly inequilateral, posterior end slightly more extended than anterior. Anterior dorsal margin slightly convex; posterior dorsal margin distinctly concave in umbonal area, straightening out to merge into narrowly rounded posterior end. Anterior end broadly rounded. Ventral margin slightly convex. Sculpture of more or less distinct growth lines. Interior inaccessible.

Length 53.2 mm, height 32.8 mm, convexity about 5 mm (type).

Type (left valve): USNM 647593.

Type locality: 125 (USGS 5852, east side of Gaillard Cut near Empire bridge; near Canal station 1876, Canal Zone). La Boca formation.

Though the left-valve corroded type is the only specimen, it is named, as it is a distinctive species in the faunas under consideration. It presumably is a species of *Psammacoma*. The somewhat trigonal-ovate outline suggests *Psammotreta*, the next genus discussed, but the posterior end has no indication of subtruncation or slight flexure. The distinctly concave posterior dorsal margin in the umbonal area is like that of the Miocene Jamaican *Psammacoma olivella* (Dall, 1890–1903, p. 1054, pl. 47, fig. 20, 1900) and the living eastern Pacific *P. siliqua* (C. B. Adams) (Turner, 1956, p. 85, pl. 19, figs. 15, 16). Both of those species, however, are small (length 23 and 19 mm, respectively) and elongate.

P. tracta (Dall, 1890–1903, p. 1053, pl. 47, fig. 13, 1900) evidently is a synonym of *P. olivella*. Though *P. tracta* has page precedence, *P. olivella* is given precedence, as the type of *P. tracta* is immature. *P. yaquensis* (Maury, 1917, p. 227, pl. 39, fig. 8; Cercado formation, Dominican Republic) is regarded as a synonym of *P. olivella*.

Occurrence: La Boca formation (early Miocene), Galliard Cut area, locality 125.

Genus Psammotreta Dall

Dall, U. S. Natl. Mus. Proc., v. 23, p. 292, 1900.

Type (orthotype): *Tellina aurora* Hanley, living, Baja California to Ecuador.

Psammotreta hadra Woodring, n. sp.

Plate 114, figures 15, 16

Large, trigonal-ovate, height 72 percent of length. Slightly inequilateral, anterior end slightly more extended than posterior. Slightly convex. Anterior dorsal margin convex; posterior dorsal margin practically straight. Anterior end broadly rounded; posterior end narrowly rounded, subtruncated and slightly flexed. Sculpture of more or less distinct growth lines, most distinct on posterior slope. Hinge of right valve: narrow anterior and bifid posterior cardinal teeth. Hinge of left valve and pallial sinus inaccessible.

Length 74 mm, height 53 mm, convexity about 6 mm (type).

Type (articulated specimen): USNM 647594.

Type locality: 170a (USGS 8411, headwaters of Quebrada Caña [Río Caño Quebrado], station 2 plus 50, Panamá), middle part of Gatun formation.

Psammotreta hadra is represented by the articulated type and a right valve, both from the middle part of the Gatun formation. On both specimens, part of the shell is missing and the valves of the type are skewed.

This large species is closely related to the living eastern Pacific *P. grandis* (Hanley) (Olsson, 1961, p. 412, pl. 67, fig. 4, pl. 68, fig. 7), which is even larger (length as great as 93 mm), more convex, and more inequilateral. No similar species is known in western Atlantic waters.

Occurrence: Middle part of Gatun formation (middle Miocene), western area, localities 170, 170a.

Genus Florimetis Olsson and Harbison

Olsson and Harbison, Acad. Nat. Sci. Philadelphia Mon. 8, p. 129, 1953.

Type (orthotype): *Tellina intastriata* Say, living, Bermuda, Bahamas, Florida to Barbados.

Coan (1971, p. 17) adopted *Leporimetis* (Iredale, 1930b, p. 74; type (orthotype): *Tellina spectablis* Hanley, living, Philippine Islands) at the generic level and possible usage of *Florimetis* at the subgeneric level. According to Hanley's illustration of his *Tellina spectabilis* (Hanley, 1846, p. 323, pl. 65, fig. 254), it is very inequilateral and has two flexures. Until that species is better known, *Florimetis* is preferred at the generic level.

Florimetis trinitaria (Dall)

Plate 102, figure 7

Metis trinitaria Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 5, p. 1041, pl. 46, fig. 24, 1900 (Miocene, Trinidad). Maury, Bull. Am. Paleontology, v. 10, no. 42, p. 121, pl. 22, figs. 1, 2, 8, 1925 (Miocene, Trinidad).

Apolymetis trinitaria (Dall), Jung, Bull. Am. Paleontology, v. 55, no. 247, pl. 34, figs. 7, 8, 1969 (Miocene, Trinidad).

Not *Metis trinitaria* (Dall), Cooke, Carnegie Inst. Washington Pub. 291, p. 148, pl. 14, figs. 2a, 2b, 1919 (Miocene, Cuba, Anguilla). Maury, New York Acad. Sci., Scientific Survey of Porto Rico and the Virgin Islands, v. 3, pt. 1, p. 42, 192, 1920 (Miocene, Puerto Rico). Hubbard, New York Acad. Sci., Scientific Survey of Porto Rico and the Virgin Islands, v. 3, pt. 2, p. 125, pl. 10, fig. 7, 1920 (Miocene, Puerto Rico). Maury, Brasil Serv. Geol. y Mineral. Mon. 4, p. 357, pl. 19, fig. 3, 1925 (Miocene, Brasil).

Tellina sagrae d'Orbigny, Guppy, Agr. Soc. Trinidad and Tobago Proc., v. 10, p. 459 (Paper 440), 1910 (separate separately paginated); reprint, Bull. Am. Paleontology, v. 8, no. 35, p. 154, 1921 (Miocene, Trinidad).

Metis trinitaria colombiensis Weisbord, Bull. Am. Paleontology, v. 14, no. 54, p. 24, pl. 5, fig. 6, 1929 (Miocene, Colombia).

Apolymetis trinitaria colombiensis (Weisbord), Marks, Bull. Am. Paleontology, v. 33, no. 139, p. 84, 1951 (Miocene, Ecuador).

Metis colombiensis Weisbord, Hodson and Hodson, Bull. Am. Paleontology, v. 16, no. 60, p. 8, pl. 4, fig. 1, 1931 (Miocene, Colombia).

Apolymetis colombiensis (Weisbord), Rutsch, Naturfors. Gesell. Basel Verh., v. 54, p. 123, pl. 6, figs. 2, 3, 1942 (Miocene, Trinidad).

Metis falconensis H. K. Hodson, *in* Hodson and Hodson, Bull. Am. Paleontology, v. 16, no. 59, p. 13, pl. 4, figs. 1, 4, 1931 (Miocene, Venezuela).

Moderately large, quadrate-ovate, height 78 to 84 percent of length, subequilateral, Strongly convex. Umbo wide. Posterior flexure moderately strong. Sculpture of very narrow, very closely spaced concentric threads, visible only on anterior part of valve. Interior unknown.

Length 60 mm, height 46.5 mm, convexity (both valves) 2.2 mm (figured specimen).

Type material: Lectotype, the articulated specimen illustrated by Dall, designated by Jung, 1969, p. 393, USNM 115660.

Type locality: Springvale Quarry, abandoned, overgrown quarry, about a mile northeast of Forres Park, on east side of stream east of road, Trinidad, Savaneta glauconitic sandstone member of Springvale formation.

Two internal molds of articulated valves, from the lower member of the Alhajuela formation, are the sole representatives of *Florimetis*. The fine sculpture is shown only on the anterior part of a latex cast of the external mold of the right valve of the smaller specimen (length 52 mm). Unfortunately, the external mold was discarded when the cast was made 25 years ago.

These two fossils are identified as *F. trinitaria*. They are smaller than the largest topotypes and the largest from Colombia (lengths 72 and 73 mm, respectively). As outlined by Jung, topotypes show a considerable range of variation in outline. The lectotype is exceptional in having a greatly extended anterior end. The remaining syntype (USNM 645187) and the specimens illustrated by Rutsch show to better advantage the average outline of topotypes.

As identified, the age range of *F. trinitaria* is late early Miocene to late Miocene. The occurrence in Pamamá is the earliest now known. It is more closely related to *F. cognata* (Pilsbry and Vanatta) (Olsson, 1961, p. 410, pl. 67, figs. 2–2d, pl. 68, fig. 10) than to the living western Atlantic *F. intastriata* (Say) (Olsson and Harbison, 1953, p. 129, pl. 15, figs. 1–1b). According to USNM collections, *F. cognata*, originally described from the Galapagos, has a mainland range from La Paz Bay, Baja California, to northern Perú. A large right valve (length 72.5 mm, height 61 mm), collected off Cedro Island, in the Gulf of Nicoya, Costa Rica (USNM 637579), is practically a duplicate of *F. trinitaria*, so far as external features are concerned.

The name *Metis trinitaria* has been abused. The fossils from Cuba, Puerto Rico, Anguilla, and Brasil so named are regarded as *Florimetis chipolana* (Dall) (1890–1903, p. 1042, pl. 47, fig. 21, 1900), or as forms of that early Miocene species from Florida. The small high Cuban fossils illustrated by Cooke are especially common in the La Cruz formation of Oriente Province.

Tellina sagrae (d'Orbigny, 1852(?), p. 56, pl. 4, figs. 8–10) was the first fossil species of *Florimetis* to be described from the Caribbean region. On the basis of the illustrations, Dall (1890–1903, p. 1043, 1900) identified it as *F. intastriata*. That identification is supported by d'Orbigny's statement in the rare text (a copy of which is in the library of the Academy of Natural Sciences of Philadelphia) that it was found near Havana in limestone containing only living species. He did not realize, however, that his species is still living and that it had already been named.

Occurrence: Lower member of Alhajuela formation (early Miocene), locality 82a. Tuburá formation (middle Miocene), Atlántico Dept., Colombia (USGS 11344, 11347). Middle Miocene deposits, Falcón, Venezuela (Hodsons' record). Daule formation (middle Miocene), Ecuador (Mark's undocumented record). Usiacurí formation (late Miocene) Atlántico Dept., Colombia (Weisbord's record). Savaneta glauconitic sandstone member and Melajo clay member of Springvale formation (late Miocene), Trinidad.

Family DONACIDAE

Genus Donax Linne

Linné, Systema naturae, 10th ed., p. 682, 1758.
Type: logotype, Schumacher, Essai d'un nouveau système des habitations des vers testacées, p. 144, Copenhagen, 1817): *Donax rugosa* [*rugosus*] Linné, living, tropical west Africa.

A small *Donax* from the Culebra formation that apparently lacks a carina is listed as *Donax* sp.

Donax gonioides Woodring, n. sp.

Plate 99, figures 10, 13, 14

Of medium size, elongate-ovate, height 61 to 69 percent of length, strongly inequilateral. Posterior carina narrow, strong. Posterior slope narrow, slightly convex. Sculpture of very narrow, very closely spaced, generally faint, radial threads, not apparent on parts, or most, of some valves. Narrow concentric threads faintly overriding radial threads on posterior slope, extending in front of carina on some valves. Hinge not clearly exposed.

Length 24 mm, height 15.5 mm, convexity 6 mm (type). Length 32.3 mm, height 20.7 mm, convexity 9 mm (largest valve).

Type (right valve): USNM 647596; paratype (left valve), USNM 647597.

Type and paratype locality: 116a (USGS 20956, east bank of Panama Canal at Canal station 2038, near Paraiso, Canal Zone), La Boca formation.

Though 45 valves of *Donax gonioides* were found in the La Boca formation, all except 21 from locality 116a are small and poorly preserved, and some of those from locality 116a itself are incomplete or more or less disfigured by matrix. The distinctness of the radial sculpture is variable.

D. gonioides is smaller, more elongate, and more inequilateral than the living *D. striata* (Linné) (Morrison, 1971, p. 561, pl. 1, fig. S)—a species of the Greater Antilles that on the mainland ranges from Belize to Rio Grande do Norte, Brasil.

Occurrence: La Boca formation (lower Miocene) Gaillard Cut area, localities 99b, 99c, 100, 116a.

Donax aff. D. asper Hanley

Plate 99, figures 8, 9

Of medium size, trigonal-ovate, height about 80 percent of length, strongly inequilateral. Posterior carina narrow, strong; valve slightly depressed in front of it. Posterior slope moderately narrow, slightly convex. Sculpture strong, narrowly reticulate, concentric threads narrower or wider than radial threads on different parts of valve. Hinge inaccessible.

Length (practically complete) 25 mm, height 20.5 mm, convexity 9 mm (figured right valve).

Five valves of this short, strongly sculptured species are associated with *Donax gonioides* at locality 116a. All are incomplete, and the illustrated valve is the only large one. The outline suggests alliance with the living eastern Pacific *D. asper* (Olsson, 1961, p. 343, pl. 59, figs. 1–1d), which ranges from the Gulf of California to northern Perú. The species from the La Boca, however, is higher and more strongly sculptured than *D. asper*. Though it evidently is new, a satisfactory type is not available.

Occurrence: La Boca formation (lower Miocene) Gaillard Cut area, locality 116a.

Donax carinatus palaius Woodring, n. subsp.

Plate 116, figures 19, 20

Of medium size, elongate-ovate, height 54 to 62 percent of length, moderately inequilateral. Posterior carina very sharp. Posterior slope narrow, slightly concave. Sculpture greatly subdued on main part of valve, revealed in slightly corroded parts as narrow, flat bands, separated by hairline striae. Sculpture on posterior slope narrowly reticulate, except in umbonal area; concentric threads stronger than radial threads. Hinge inaccessible.

Length 24.5 mm, height 15 mm, convexity 4.5 mm (type).

Type (left valve): USNM 647599.

Type locality: 161c (USGS 8382, railroad cuts west of Gatun Dam, station B, Canal Zone), middle part of Gatun formation.

Donax carinatus palaius is based on the left-valve type and an immature right valve, both from the middle part of the Gatun formation. The sculpture is of the same type as that of the larger nominate subspecies (Olsson, 1961, p. 342, pl. 60, figs. 4–4b) but is more subdued on the main part of the valve. On the nominate subspecies, which ranges from Sinaloa, México, to northern Perú, the sculpture shows through the glazed surface.

Occurrence: Middle part of Gatun formation (middle Miocene), western area, localities 161c, 170a.

Family PSAMMOBIIDAE

Subfamily PSAMMOBIINAE

Genus Gari Schumacher

Schumacher, Essai d'un nouveau système des habitations des vers testacées, p. 131, Copenhagen, 1817.

Type (Internat. Comm. Zoological Nomenclature, Opinion 910, 1970): *Gari vulgaris* Schumacher, living, western Pacific Ocean.

Subgenus Gobraeus Brown

Brown, Illustrations of the Recent conchology of Great Britain and Ireland, p. 102, cited, as *Gobraeus vespertinus* (as of Leach ms.), in synonymy of *Psammobia vespertina*, London, 1844. For availability, see International code of zoological nomenclature, 2d ed., p. 11, 1964.

Type (monotype): *Gobraeus vespertinus* [Gmelin] (*Solen vespertinus* Gmelin), living, northern eastern Atlantic Ocean and Mediterranean Sea.

Poorly preserved valves from the La Boca formation are listed as *Gari* sp.

Gari (Gobraeus) listrota listrota Woodring, n. sp. and subsp.

Plate 90, figures 7, 13

Of medium size, elongate-semielliptical, height 54 to 66 (generally 58 to 66) percent of length. Decidedly inequilateral, anterior end more extended than posterior. Slightly convex. Anterior dorsal margin practically straight or barely convex. Both ends broadly rounded, posterior end more broadly than anterior. Extreme posterior part slightly flattened on some valves. Sculpture limited to irregularly spaced growth lines, some exaggerated. Hinge and pallial sinus unknown.

Length 34.5 mm, height 20 mm, convexity about 3 mm (type). Length (almost complete) 40 mm, height 23.5 mm, convexity about 4 mm (paratype, largest valve).

Type (right valve): USNM 135238; paratype (right valve) USNM 647601.

Type locality 40a (USGS 2683, Vamos Vamos, lot 1, Canal Zone), marine rocks of late Eocene age; paratype locality 41 (USGS 17716, east side of promontory 375 m southeast of Palenquilla Point, west of Barro Colorado Island, Canal Zone; loose calcareous concretions at water's edge), marine rocks of late Eocene age.

Gari listrota listrota is conspicuous in collections from Vamos Vamos and Palenquilla Point: 10 and 25 valves, respectively, at those two localities. They range in length from 8 to 40 mm. The type is from one of Robert T. Hills' 1895 collections from Vamos Vamos.

Most of the valves are internal molds, but many retain more or less shell material. The interior of a left valve, minus the umbonal area, shows no indication of the adductor scars or pallial sinus, so it is not known whether the sinus is detached and relatively short, like that of the early Tertiary subgenus *Garum* (Dall, 1890–1903, pt. 5, p. 975, 1900; type (orthotype): *Psammobia dutemplis* Deshayes, Eocene, Paris basin). Davies (1935, p. 144) noted that many Eocene species are characterized by a detached and relatively short pallial sinus—a feature Dall included in his diagnosis of *Garum*. In any event, *G. listrota listrota* has the size, general outline, and sculpture of *Gobraeus* and is regarded as the earliest form of that subgenus in the Tertiary Caribbean province. Cossmann and Pissarro's illustrations of *G. loustauae* Cossmann (1904–1906, pl. 8, figs. 41–5), a small, elongate species from the Lutetian of the Paris basin, show the sinus of *Gobraeus*.

The decidedly inequilateral outline of the fossils from the marine rocks of late Eocene age is like that of the species from the Inglis limestone (of former usage) of Florida identified as *Gari jacksonense* [*jacksonensis*] (Richards, *in* Richards and Palmer, 1953, p. 53, pl. 12, fig. 4), although the type of that species is almost equilateral (Harris, *in* Harris and Palmer, 1946–47, pt. 1, p. 97, pl. 21, figs. 12–14, 1946).

Occurrence: Marine rocks of late Eocene age, localities 40a, 40d, 41, 41a, 41b.

Gari (Gobraeus) listrota hadratera Woodring, n. subsp.

Plate 91, figures 7, 12

Of medium size, outline like that of *Gari listrota listrota*, but larger. Height 58 to 65 percent of length. Sculpture limited to closely spaced growth lines near margins of valves, possibly effaced elsewhere. Hinge and pallial sinus unknown.

Length 41.3 mm, height 24 mm, convexity about 3 mm (type). Length 47 mm, height 29.7 mm, convexity about 4 mm (paratype, largest specimen).

Type (right valve): USNM 647602; paratype (left valve) USNM 647603.

Type and paratype locality: 42d (USGS 18837, Barro Colorado Island, northern part of island, stream heading west of Miller Trail near Miller 17, about 100 m above mouth, Canal Zone), upper part of Bohio formation.

It was surprising to find 18 specimens (two articulated) of *G. listrota hadratera*, ranging in length from 24 to 47 mm, in marine lenses in the upper part of the Bohio formation on Barro Colorado Island. Though some are internal molds, most retain at least some shell material, and a few retain all, or almost all, of the shell.

This subspecies is distinguished from the nominate subspecies by its larger size; that is, the two subspecies form a lineage graded in increasing size with decreasing age. In addition, *G. listrota hadratera* is sculptured with closely spaced growth lines near the margin of valves. The lineage evidently is continued by the living eastern Pacific *G. panamensis* (Olsson, 1961, p. 357, pl. 63, fig. 11). If so, a long gap intervenes between late Oligocene and the present time, a gap during which little increase in size took place.

Occurrence: Bohio formation (late Oligocene), localities 42d, 42g.

Subfamily SANGUINOLARIINAE

Genus Sanguinolaria Lamarck

Lamarck, Soc. Histoire Nat. Paris Mem., p. 84, 1799.
Type (monotype): *Solen sanguinolentus* Gmelin, living, western Pacific Ocean.

Subgenus Sanguinolaria s.s.

Sanguinolaria (Sanguinolaria) aff. S. tellinoides A. Adams

Plate 115, figure 12

Large, ovate, height about 63 percent of length. Moderately inequilateral, posterior end moderately more extended than anterior. Slightly convex. Posterior dorsal margin slightly concave in umbonal area. Anterior end broadly rounded, extreme posterior end missing. Sculpture only of irregularly spaced growth lines, exaggerated here and there. Faint radial lineation on ventral part of illustrated valve. Hinge and pallial sinus unknown.

Length (incomplete) 58 mm (estimated restored length 65 mm), height 41.2 mm, convexity about 6 mm (figured right valve).

Two right valves from the lower part of the Gatun formation are the only representatives of *Sanguinolaria*. The extreme posterior end of both is missing, but it can be seen that the posterior end is narrower than the anterior. The smaller valve (estimated restored length 55 mm is greatly corroded.

These valves from the Gatun are closely related to the living eastern Pacific *S. tellinoides* (Keen, 1971, p. 244, fig. 611), which reaches a length of 90 mm and ranges from the Gulf of California to Ecuador. It occurs in the Pliocene of Ecuador (Pilsbry and Olsson, 1941, p. 72).

Occurrence: Lower part of Gatun formation (middle Miocene), locality 138f.

Family SOLECURTIDAE

Subfamily SOLECURTINAE

Genus Solecurtus Blainville

Blainville, Dictionnaire des sciences naturelles, pt. 2, Règne, organisé, v. 32, p. 351, 1824.
Type (logotype, Anton, Verzeichniss der Conchylien welche sich in der Sammlung von Hermann Eduard Anton befinden, p. 1, Halle, 1839): *Solecurtus strigilatus* Blainville = *Solen strigilatus* Linné, living, Mediterranean Sea.

A poorly preserved left valve from the Culebra formation is listed as *Solecurtus* sp.

Solecurtus vicksburgensis Aldrich

Plate 91, figure 11

Solecurtus vicksburgensis Aldrich, Cincinnati Jour. Nat. History, v. 8, p. 145, pl. 2, fig. 1, 1885 (Oligocene, Mississippi).
Macha vicksburgensis (Aldrich), Aldrich, Alabama Geol. Survey Bull. 1, p. 37, pl. 2, fig. 1, 1886 [Oligocene, Mississippi].
Psammosolen vicksburgensis (Aldrich), Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 5, p. 960, 1900 (Oligocene, Mississippi, and other localities).

Small, elongate-elliptical, height 45 percent of length. Very inequilateral, umbo at about anterior third of dorsal margin. Slightly convex. Sculpture of narrow, closely spaced threads, parallel to posterior margin at posterior end of dorsal margin, then swinging obliquely forward to ventral margin. Elsewhere, threads oblique throughout their length (extreme anterior end of valve missing). Interior inaccessible.

Length 26.4 mm, height 11.8 mm, convexity about 4 mm (figured left valve).

Type: USNM 644607.

Type locality: Vicksburg, Miss., Mint Springs marl member of Marianna limestone or Byram formation.

A left valve recovered from a marine lens in the upper part of the Bohio formation of Barro Colorado Island is identified as *Solecurtus vicksburgensis*, the earliest American species of the genus. It closely resembles the type of that species.

S. vicksburgensis is like a minature *S. strigilatus*, except that the oblique threads of the American species are more closely spaced.

Occurrence: Bohio formation (late Oligocene), locality 42d. Mint Springs marl member of Marianna limestone or Byram formation (middle Oligocene), Mississippi.

Solecurtus aff. S. broggii gatunensis Toula

The La Boca formation yielded an incomplete left valve and two incomplete left internal molds of *Solecurtus*. Two of them show indications of widely spaced oblique sculpture on the posterior part, like that characteristic of *S. broggii gatunensis*, the next form described. Like many forms from the La Boca that left descendants in the Gatun formation, the predecessors are smaller than the descendants.

Length (incomplete) 24 mm (estimated restored length 35 mm), height 15 mm, convexity about 5.5 mm (largest specimen).

Occurrence: La Boca formation (early Miocene), Gaillard Cut area, localities 99c, 99h, 116a.

Solecurtus broggii gatunensis Toula

Plate 115, figures 21, 22

Solecurtus gatunensis Toula, K. k. Geol. Reichsanstalt Jahrb., v. 58, p. 733, pl. 28, fig. 12, 1909 (Miocene, Canal Zone). Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 63, p. 372, 1911 (Miocene, Canal Zone, Toula's record).

Solecurtus (*Macha*) *strigillatus* [*strigilatus*] (Linné), Toula, K. k. Geol. Reichsanstalt Jahrb., v. 58, p. 731, pl. 27, fig. 11 (not fig. 12), text-fig. 11, 1909 (Miocene, Canal Zone). Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 63, p. 372, 1911 (Miocene, Canal Zone, Toula's record).

Psammosolen gatunensis costaricensis Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 260, pl. 29, fig. 7, 1922 (Miocene, Costa Rica).

Large, elongate-elliptical, height 36 to 43 (42 or 43, except largest specimens) percent of length. Very inequilateral, umbo at about anterior third of dorsal margin. Convexity moderately strong. Sculpture of fine, very closely spaced growth lines, exaggerated here and there, strongly exaggerated at anterior end. At posterior end thin, widely spaced lamellae parallel to growth lines at dorsal margin, then swinging obliquely forward across growth lines. Lamellae disappearing along alinement extending from about umbo obliquely forward. Short, anteriormost lamellae, in or near umbonal area, not as widely spaced as elsewhere. Right hinge: anterior cardinal tooth dorsal surface bifid, and narrower, oblique, bifid cardinal tooth. Left hinge and pallial sinus inaccessible.

Length 79.8 mm, height 28.5 mm, convexity 10 mm (figured left valve). Length 87.3 mm, height 33 mm, diameter 11 mm (figured right valve of articulated specimen, largest specimen).

Type: Paläontologisches Inst., Univ. Wien.

Type locality: Presumably Gatun Locks excavation, Canal Zone, middle part of Gatun formation.

Though *Solecurtus broggii gatunensis* is widespread in the Gatun at 13 localities, only 19 specimens, ranging in length from 17 to 87.3 mm, were collected. Some are badly corroded. On a right valve of medium size (locality 139g, length 39 mm) the oblique lamellae are exceptionally low. According to Toula's illustration, the posterior end of the type is not well preserved, but his text illustration of a right valve he identified as *S. strigillatus* [*strigilatus*] shows the sculpture to better advantage.

Perhaps the fossils from the Gatun are not to be distinguished from the nominate subspecies (Pilsbry and Olsson, 1941, p. 71, pl. 18, fig. 4; illustrated specimen, the type, a living Ecuadoran specimen), at least on external features. Hertlein and Strong, 1950, p. 228) commented on the close similarity of *S. gatunensis* and the eastern Pacific species.

The fossils from the Culebra, the Gatun, and the Pliocene Jama formation of Ecuador constitute a graded lineage—graded in increasing size with decreasing age. The living specimens, however, are not similarly graded. According to Pilsbry and Olsson (1941), fragments from the Jama indicate a size larger than living specimens.

As noted by Dall (1890–1903, pt. 5, p. 985, 1900), *Tagelus lineatus* (Gabb, 1881b, p. 370, pl. 47, fig. 71), from the Pliocene Moín formation of Costa Rica, is a species of *Psammosolen;* that is, *Solecurtus*. The posterior part of the shell lacks oblique sculpture.

Occurrence: Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, localities 137, 138c, 138e. Middle part, eastern area, localities 139f, 139g, 145, 147, 152, 153, 159d; western area, localities 160, 162a. Upper part, western area, locality 182a. Deposits of middle Miocene age, Limón Province, Costa Rica.

Genus Tagelus Gray

Gray, Zoological Soc. London Proc., p. 189, 1847.

Type (orthotype): *Sol*[*en*] *guinensis* [*Solen guineensis* Wood, 1815 = *Solen adansonii* Bosc, 1801], living, tropical eastern Atlantic Ocean.

Subgenus Tagelus s.s.

Tagelus (Tagelus) orthrius Woodring, n. sp.

Plate 91, figure 8

Of medium size, elongate-elliptical, height 42 or 43 percent of length, equilateral, slightly convex. Anterior dorsal margin slightly convex; posterior dorsal margin slightly concave. Both ends broadly rounded, posterior end more abruptly rounded than anterior. Sculpture limited to inconspicuous growth lines. Interior inaccessible.

Length 30.5 mm, height 13 mm, convexity about 3 mm (type, largest specimen).

Type (right valve): USNM 647608.

Type locality: 42f (USGS 18836, northern part of Barro Colorado Island, stream southeast of Fuertes House, about 355 m above mouth, from slide on west side of stream, Canal Zone), upper part of Bohio formation.

Ten specimens of *Tagelus orthrius* were found in marine lenses in the upper part of Bohio formation of Barro Colorado Island. The length range is about 14 to 30.5 mm. Parts of the shell are missing on all specimens; in fact, on the type, most of the shell is missing. This species is the earliest species of *Tagelus* s.s. to be recorded from the Tertiary Caribbean province. In general features it is similar to the much larger western Atlantic *T. gibbus* (Spengler), which ranges back to late Miocene.

Occurrence: Bohio formation (late Oligocene): Localities 42f, 42i.

Subgenus Mesopleura Conrad

Conrad, Am. Jour. Conchology, v. 3, appendix, p. 23, 1865.

Type (logotype, Stoliczka, India Geol. Survey Mem., Palaeontologia Indica, Cretaceous fauna of southern India, v. 3, p. XVI, 1870): *Solen bidentatus* Spengler = *Solen divisus* Spengler, living, Massachusetts to northern Brasil.

Tagelus (Mesopleura) divisus (Spengler)?

Plate 117, figure 8

Small, thin-shelled, elongate-subelliptical, height about 36 percent of length. Slightly inequilateral, anterior end slightly more extended than posterior. Slightly convex. Dorsal margins practically straight. Both ends broadly rounded, posterior end more abruptly rounded than anterior. Sculpture limited to inconspicuous growth lines. Low internal rib extending downward from umbo. Hinge of right valve: two diverging cardinal teeth, posterior one more oblique and slightly wider than anterior. Hinge of left valve: two narrow cardinal teeth, anterior one practically vertical, posterior one horizontal. Pallial sinus unknown.

Length 22 mm, height 8 mm, convexity about 3 mm (figured right valve, largest specimen).

The lower part of the Gatun formation yielded five small valves of a species of the subgenus *Mesopleura*. Incomplete, very small right and left valves (estimated restored lengths 6 and 8 mm, respectively) show the hinge and internal rib.

No features are apparent to distinguish these fossils from immature *Tagelus divisus*. The identification is questioned, however, until a larger sample indicates whether the largest is immature or mature. A suite of fragments from the lower Miocene Chipola formation of Florida, the largest of which indicates an estimated restored length of about 30 mm, throws doubt on a progressive increase in size correlated with decreasing age. Gardner (1926–47, p. 215, 1928) identified the fossils from the Chipola as *Tagelus* (*Mesopleura*) cf. *T. divisus*. Her illustration, however, is the interior of a living right valve collected at Charlotte Harbor, Fla. (USNM 27437), mislabelled in the explanation of the plate.

T. divisus (Warmke and Abbott, 1961, p. 202, pl. 42, fig. 1), which reaches a length of 40 to 50 mm, has an extensive range from Massachusetts to northern Brasil. It is recorded from formations as old as late Miocene.

Occurrence: Lower part of Gatun formation (middle Miocene), localities 138c, 138d, 138e.

Family SEMELIDAE

Genus Semele Schumacher

Schumacher, Essai d'un nouveau système des habitations des vers testacées, p. 165, Copenhagen, 1817.

Type (monotype): *Tellina reticulata* Spengler, not *Tellina reticulata* Linné, = *Tellina proficua* Pulteney, living, North Carolina to Gulf of San Jorge, Argentina.

A small (length 17 mm), possibly immature, equilateral left internal mold from the Caimito formation of Barro Colorado Island is listed as *Semele* sp.

Semele species

Plate 87, figure 11

Of medium size, ovate, height 72 percent of length. Slightly inequilateral, anterior end slightly more extended than posterior. Slightly convex. Dorsal margins almost straight, posterior margin sloping more steeply than anterior. Anterior end broadly rounded; posterior end narrowly rounded. Extreme posterior part of valve slightly flattened. Minute patch of corroded shell showing fairly closely spaced concentric threads and fine, closely spaced radial threadlets. Hinge and pallial sinus unknown.

Length 39 mm, height 28 mm, convexity about 4 mm (figured right internal mold).

The outline and meager representation of the sculpture of a right internal mold, from the marine rocks of the late Eocene age at Palenquilla Point, indicate that it is a species of *Semele*. It retains very little shell material. It is large for an early Tertiary species and evidently is new.

Occurrence: Marine rocks of late Eocene age locality 41b.

Semele cf. S. venusta (Reeve)

Plate 91, figure 23

Moderately large, ovate, height 75 percent of length. Slightly inequilateral, anterior end slightly more extended than posterior. Slightly convex. Anterior dorsal margin slightly concave; posterior dorsal margin convex. Both ends broadly rounded. Extreme posterior part of valve slightly flattened. Traces of low, closely spaced concentric lamellae. Two cardinal teeth showing on mold. Remainder of interior unknown.

Length 51 mm, height 38.5 mm, convexity about 6 mm (figured left internal mold).

Like the preceding species, a left internal mold of *Semele*, from the Bohio formation of Barro Colorado Island, evidently is new and is large for an early Tertiary species. The outline is somewhat like that of the living eastern Pacific *S. venusta* (Olsson, 1961, p. 370, pl. 66, figs. 1, 1a). The fossil from the Bohio, however, is larger and its anterior dorsal margin is slightly concave.

Occurrence: Bohio formation (late Oligocene), locality 42d.

Semele chipolana Dall

Plate 102, figures 3, 4

Semele chipolana Dall, Wagner Free Inst. Sci., v. 3, pt. 5, p. 986, pl. 37, fig. 3, 1900 (Miocene, Florida). Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 64, p. 517, 1913 (Miocene, Canal Zone). Gardner, U. S. Geol. Survey Prof. Paper 142-E, p. 204, pl. 31, fig. 7 (Dall's illustration), 1928 (Miocene, Florida).

Semele sp. cf. *S. chipolana* Dall, Gardner, Florida Dept. Conservation, Geol. Bull. 14, p. 41, pl. 7, figs. 5–7, 1936 (Miocene, Florida).

Semele perlamelloides Maury, Bull. Am. Paleontology, v. 4, no. 21, p. 37, pl. 9, fig. 8, 1910 (Miocene, Florida).

?*Semele quirosana* H. K. Hodson, Bull. Am. Paleontology, v. 16, no. 59, p. 17, pl. 9, figs. 8, 12, 1931 (Miocene, Venezuela).

Moderately large, ovate, height 70 to 87 (generally 76 to 83) percent of length. Equilateral to slightly inequilateral, anterior end slightly more extended than posterior. Convexity moderately strong. Anterior dorsal margin practically straight or slightly concave; posterior dorsal margin slightly convex. Anterior end broadly rounded; posterior end broadly rounded, exceptionally subtruncated. Extreme posterior part of valve slightly flattened. Sculpture of low, closely spaced lamellae. Interior unknown.

Length 43.5 mm, height 34.5 mm, convexity about 7.5 mm (figured left valve from La Boca formation). Length 50 mm, height 39.2 mm, convexity (both valves) 14 mm (figured left valve of articulated specimen from upper member of Alhajuela formation, largest specimen).

Type: USNM 114630.

Type locality: USGS 2211, lower bed at Alum Bluff on Apalachicola River, Liberty County, Fla., Chipola formation.

Semele chipolana is fairly common in the La Boca formation: a total of 39 specimens, about equally divided as right valves, left valves, and articulated specimens. All five collected at locality 101h are articulated, but none is large. The range in length is 16 to 47.5 mm. The species occurs also in the Emperador limestone member of the La Boca (two specimens) and in the upper member of the Alhajuela formation (one specimen).

The fossils from the La Boca are internal molds, but at least some sculpture is preserved on about two-thirds of them. Brown and Pilsbry recognized as *S. chipolana* an internal mold from the La Boca in the Tower N area. They recorded an ample pallial sinus extending beyond the middle of the valve. Two of the specimens from the Emperador and the single specimen from the Alhajuela also are internal molds.

The sample from the La Boca shows a considerable range of variation in the ratio of height to length and in the degree of approximation to equilaterality. The meager sample from the Chipola also shows some variation. As now known, *S. quirosana*, from the outcropping La Rosa formation of Venezuela, is distinguishable from *S. chipolana* only by its small size (length 25.5 mm).

S. chipolana is similar in outline and sculpture to the living western Atlantic *S. purpurascens* (Gmelin) (Boss, 1972, p. 15, pl. 5, fig. D, pl. 6, figs. A–D, pl. 7, fig. E, pl. 8, fig. D, pl. 10, fig. C) and its living eastern Pacific analog *S. sparsilineata* Dall (Olsson, 1961, p. 363, pl. 66, fig. 7) but is 50 percent larger.

Occurrence: La Boca formation (early Miocene), Gaillard Cut area, localities 99a, 99c, 99d, 99g, 101a, 101h, 114, 115, 115a, 119a. Emperador limestone member of La Boca formation (early Miocene), Gaillard Cut area, locality 118b; Madden basin, locality 73. Upper member of Alhajuela formation (early Miocene), locality 89. Chipola formation (early Miocene), Florida. Oak Grove sand member of Shoal River formation (middle Miocene), Florida.

Semele cf. S. perlamellosa Heilprin

Plate 117, figure 28

Of medium size, subelliptical, height 69 to 73 percent of length, practically equilateral, slightly convex. Anterior dorsal margin slightly concave, posterior dorsal margin practically straight. Both ends broadly rounded, posterior end less broadly rounded than anterior and subtruncated. Extreme posterior part of valve slightly flattened. Low, fairly narrowly spaced concentric lamellae preserved on small patch of shell; similar sculpture impressed on entire surface of internal molds. Hinge of right valve worn but showing slender anterior and wider posterior cardinal teeth; anterior lateral tooth preserved. Left hinge and sinus unknown.

Length 45.8 mm, height 33.5, convexity (both valves) 13.6 mm (figured specimen).

Three internal molds and the interior of a right valve from the middle part of the Gatun formation and an incomplete internal mold from the Toro limestone member of the Chagres sandstone are similar in outline and sculpture to *Semele perlamellosa* (Dall, 1890–1903, pt. 5, p. 992, pl. 37, figs. 4, 5, 1900; Pliocene, Florida). That species reaches a length of 80 mm.

Occurrence: Middle part of Gatun formation (middle Miocene), western area, localities 160, 162a. Toro limestone member of Chagres sandstone (late Miocene or early Pliocene), locality 196.

Semele laevis costaricensis Olsson

Plate 115, figures 19, 20; plate 117, figure 20

Semele laevis Sowerby, var. *costaricensis* Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 258, pl. 29, fig. 1, 1922 (Miocene, Costa Rica). Haas, Jour. Paleontology, v. 16, p. 309 (list), 1942 (Costa Rica, locality unknown, presumably Miocene).

Semele laevis costaricensis Olsson, Hodson and Hodson, Bull. Am. Paleontology, v. 16, no. 59, p. 17, pl. 8, fig. 5, 1931 (Miocene, Venezuela). Olsson, Bull. Am. Paleontology, v. 19, no. 68, p. 126, 1932 (Miocene, Perú). Jung, Bull. Am. Paleontology, v. 55, no. 247, p. 397, pl. 36, figs. 1, 2, 1969 (Miocene and Pliocene, Trinidad).

Semele cf. *costaricensis* Olsson, Olsson, Neogene mollusks from northwestern Ecuador, p. 65, pl. 9, fig. 9, Paleontological Research Inst., 1964 (Miocene, Ecuador).

Erycina turbacoensis Anderson, California Acad. Sci. Proc., 4th ser., v. 18, no. 4, p. 163, pl. 22, figs. 9, 10, 1929 (Miocene, Colombia).

Large, ovate, height 68 to 87 (generally 73 to 79) percent of length. Slightly inequilateral, anterior end slightly more extended than posterior. Convexity moderately strong. Anterior dorsal margin slightly concave at umbo, otherwise straight; posterior dorsal margin slightly convex. Both ends broadly rounded, posterior end generally more broadly rounded than anterior. Narrow posterior slope generally distinct through flattening. Much of valve smooth, aside from irregularly spaced growth lines. Closely and irregularly spaced striae generally present at posterior end, and exceptionally elsewhere near margins. Faint radial lineation on parts of some valves. Interior unknown.

Length 57.6 mm height 48.7 mm, convexity (both valves) 19.5 mm (figured short specimen). Length 69.7 mm, height 47.3 mm, convexity (both valves) 21.5 mm (figured elongate specimen).

Type: Paleontological Research Inst. 21287.

Type locality: Río Banano, Limón Province, Costa Rica, deposits of middle Miocene age.

Semele laevis costaricensis is widespread and locally common in the lower and middle parts of the Gatun formation: 51 specimens, ranging in length from 31.3 to an estimated 75 mm. Articulated specimens are almost twice as abundant as disarticulated valves. All 18 from the lower part of the Gatun at Stanford University locality 136a are articulated. Some specimens from the middle part are internal molds.

A wide range of variation in length, from short to elongate, is apparent. The six specimens from the middle part at locality 139g, one of which is illustrated (pl. 117, fig. 20), are elongate and large.

Many years ago, Olsson recognized the affinities of this *Semele*. It is a predecessor of the living eastern Pacific *S. laevis laevis*, distinguished by its smaller size. Living specimens of the nominate subspecies reach a length of 91.5 mm. In the Pliocene of Ecuador it is even larger: as long as 100 mm (Pilsbry and Olsson, 1941, p. 70). The subspecies from the Gatun is larger than any living western Atlantic species and also larger than any other Tertiary western Atlantic *Semele*. It was widely distributed and survived until Pliocene time in Trinidad.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, localities 136, 136a, 138, 138c, 138f, 138i. Middle part, eastern area, localities 139g, 143, 144a, 145, 146, 147, 150a, 153, 155. Deposits of middle Miocene age, Limón Province, Costa Rica. Tubará formation (middle Miocene), Atlántico Dept., Colombia. Urumaco formation (middle or late Miocene), Venezuela. Angostura formation (middle Miocene), Ecuador. Upper part of Zorritos formation (middle Miocene), Perú. Gransul clay and Melajo clay members of Springvale formation (late Miocene), Trinidad. Courbaril member of Morne l'Enfer formation (Pliocene), Trinidad.

Semele sayi Toula

Semele sayi Toula, K. k. Geol. Reichsanstalt Jahrb., v. 58, p. 730, pl. 28, fig. 17, 1909 (Miocene, Canal Zone). Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 63, p. 368, 1911 (Miocene, Canal Zone, Toula's record). Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 258, pl. 29, fig. 8, 1922 (Miocene, Costa Rica).

Semele sayi is not recognized in any of the collections under study. According to Toula's description and illustration, it has the outline of a small *S. laevis costaricensis*. The posterior slope, however, is distinctly set off, and the sculpture consists of very fine, very closely spaced concentric threads.

Length 31 mm, height 23.5 (type, quoted from Toula).

Type (right valve): Paläeontologisches Inst., Univ. Wien.

Type locality: Presumably Gatun Locks excavation, middle part of Gatun formation.

Occurrence: Middle part of Gatun formation (middle Miocene), eastern area (Toula's record). Deposits of middle Miocene age, Limón Province, Costa Rica (Olsson's record).

Genus Abra Lamarck

Lamarck, Histoire naturelle des animaux sans vertébres, v. 5, p. 492, cited, as *Abra tenuis* Leach, in synonymy of *Amphidesma tenuis*, Paris, 1818. For availability see International code of zoological nomenclature, 2d ed., p. 11, 1964.

Type (monotype): *Abra tenuis* Leach = *Mactra tenuis* Montagu, living, eastern North Atlantic Ocean and Mediterranean Sea.

Subgenus Abra s.s.

Abra (Abra) lioica (Dall)?

Plate 115, figure 1

Small, ovate, height about 80 percent of length. Inequilateral, anterior end more extended than posterior. Convexity moderately strong. Anterior dorsal margin slightly concave at umbo, otherwise straight, posterior dorsal margin straight. Anterior end broadly rounded; ventral half of posterior end missing; growth lines indicate that it is more narrowly rounded than anterior end. Sculpture of irregularly spaced growth lines near margins of valve. Interior cardinal area of left valve missing; pallial sinus indistinct. Right valve unknown.

Length (incomplete) 6.5 mm (estimated restored length 7.5 mm), height 6 mm, convexity 1.5 mm (figured left valve).

A not-quite-complete left valve, found by R. T. Hill in the upper part of the Gatun formation, is the sole representative of the genus *Abra*. Its outline is like that of *A. lioica* (Dall, 1886, p. 278, pl. 4, fig. 8). *A. triangulata* Dall (Woodring, 1925, p. 179, pl. 25, figs. 3, 4; Miocene, Jamaica) is less inequilateral.

A. lioica is a living species ranging from North Carolina to Santa Caterina, Brasil.

Occurrence: Upper part of Gatun formation (middle Miocene), locality 173a.

Family KELLIELLIDAE

Genus Alveinus Conrad

Conrad, Am. Jour. Conchology, v. 1, p. 183, 1865.

Type (monotype): *Alveinus minutus* Conrad, Eocene, Mississippi.

Though *Alveinus* was first listed on p. 10 of the same volume, the only species listed was *A. parva* Conrad, a nude name.

Wherever the genus has been found, it did not survive later than middle Miocene time.

Alveinus aff. A. rotundus Dall

Minute, trigonal-ovate, height and length equal. Distinctly inequilateral, posterior end more extended than anterior. Strongly convex. Umbo high, full. Anterior dorsal margin slightly concave; posterior dorsal margin barely convex. Anterior end more broadly rounded than posterior. Shell replaced by calcite, growth lines not apparent. Hinge not clearly exposed.

Length 1.7 mm, height 1.7 mm, convexity about 1 mm (left valve).

In general features, a left valve from the La Boca formation is similar to *Alveinus rotundus*, the next species, especially in the high full umbo and the slight convexity of the posterior dorsal-lateral margin. It is, however, distinctly inequilateral, and in that feature is similar to the Eocene type species.

Occurrence: La Boca formation (early Miocene), Gaillard Cut area, locality 101.

Alveinus rotundus Dall

Plate 117, figures 3, 4, 6, 7

Alveinus rotundus Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 5, p. 1167, pl. 45, figs. 25, 28, 1900 (Miocene, Florida). Gardner, U. S. Geol. Survey Prof. Paper 142–C, p. 128, pl. 21, figs. 13, 14, 1926 (Miocene, Florida).

Alveinus rotundatus [error for *rotundus*] Dall, Harris, Palaeontographica Americana, v. 1, no. 2, p. 9, fig. 6, 1920 (Miocene, Florida).

Alveinus micculus Gardner, U. S. Geol. Survey Prof. Paper 142–C, p. 128, pl. 21, figs. 15, 16, 1926 (Miocene, Florida). Mansfield, Florida Geol. Survey Bull. 8, p. 108, pl. 21, figs. 5, 9, 10, 1932 (Miocene, Florida).

Alveinus abundans Olsson, Neogene mollusks from northwestern Ecuador, p. 45, pl. 38, figs. 2–2b, Paleontological Research Inst., 1964 (Miocene, Ecuador).

Minute, trigonal-ovate, height and length equal, or practically equal. Equilateral, or practically equilateral. Strongly convex. Umbo high, full. Anterior dorsal margin slightly concave at umbo, posterior dorsal margin barely convex. Anterior end more broadly rounded than posterior. Surface polished; subdued, irregularly spaced growth lines on ventral part of valve. Hinge of right valve: two anterior cardinal teeth parallel or subparallel to hinge-plate margin; upper tooth closer to resilifer than lower tooth. Hinge of left valve: seven-shaped cardinal tooth, open ventrally, long arm curved; arms almost, or entirely, separated on some valves. Pallial sinus indistinct.

Length and height 1.6 mm, convexity about 1 mm (figured right valve). Length and height 2.1 mm, convexity about 1 mm (a representative of fairly large valve).

Type material: 15 syntypes USNM 114658.

Type locality: USGS 2213, Chipola River, 1 mile below Baileys Ferry, Calhoun County, Fla., Chipola formation.

Several hundred specimens of *Alveinus rotundus* are in collections from the Gatun formation. They are especially abundant in collections from localities 138a, in the lower part of the formation, and 139g, 147i, and 169, in the middle part.

These minute fossils are a little smaller than those from the Chipola formation, which reach a length of 1.9 mm. The left-valve syntype of *A. micculus* is exceptionally large (length 2.3 mm), but no other valve from the Shoal River formation approaches that dimension. The type of *A. abundans* is somewhat inequilateral. Other Ecuadorian specimens are equilateral, or practically equilateral.

Occurrence: Chipola formation (early Miocene), Florida. Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, localities 136a, 138, 138a, 138b, 138c, 138d, 138e, 138f, 138g, 138h. Middle part, eastern area, localities 139c, 139e, 139f, 139g, 147f, 147h, 147i, 153a, 155; western area, locality 169. Upper part, eastern area, locality 163; western area, locality 185. Shoal River formation (middle Miocene), Florida. Angostura formation (middle Miocene), Ecuador.

Family CORBICULIDAE

Genus Polymesoda Rafinesque

Rafinesque, Annales Génerales des Sciences Physiques, v. 5, p. 319, Bruxelles, 1820.

Type (monotype): *Cyclas caroliniana* Boss, living in rivers, North Carolina to Texas.

Polymesoda cf. P. aequilatera (Deshayes)

Plate 91, figure 24

Small, thin shelled, trigonal-ovate, height slightly greater than length, almost equilateral. Slightly convex. Umbo high, narrow. Anterior dorsal margin slightly concave, posterior dorsal margin barely convex. Sculpture of irregularly spaced growth lines, strongest on anterior-ventral part of valve. Hinge and pallial line unknown.

Length 20.7 mm, height 21.4 mm, convexity about 4 mm (figured specimen).

A right valve of a corbiculid was found in a mixed fresh-water—brackish-water, marine association in the upper part of the Bohio formation of Barro Colorado Island. Though the interior is unknown, the type of sculpture indicates the genus *Polymesoda*. The valve is somewhat similar to *P. aequilatera* (Altena, 1971, p. 63, pl. 6, figs. 4–6), living in northern South America. It is, however, smaller than that species and its height is slightly greater than the length.

Occurrence: Bohio formation (late Oligocene), locality 42f.

Family PISIDIIDAE

Genus Pisidium Pfeiffer

Pfeiffer, Naturgeschichte deutscher Land- und Süsswasser-Mollusken, pt. 1, p. 123, Weimar, 1821.

Type (logotype, Gray, Zool. Soc. London Proc., p. 184–185, 1847): *Tellina amnica* Müller, cited by Pfeiffer in synonymy of *Psidium obliquum* (Lamarck), living, western Europe.

Pisidium, with *Tellina amnica* as the type species, was placed on the Official List of Generic Names in Zoology in Opinion 335 of the International Commission on Zoological Nomenclature, issued in 1955.

Pisidium atopum Woodring, n. sp.

Plate 87, figure 12

Large for the genus, very thin shelled, subquadrate, slightly inequilateral. Strongly convex. Anterior dorsal-lateral margin slightly convex; posterior dorsal-lateral margin strongly convex. Anterior end more narrowly rounded than posterior. Umbo low, wide. Sculpture of few inconspicuous growth lines. Interior inaccessible.

Length 10.6 mm, height 8 mm, convexity about 3.5 mm (type).

Type (right valve): USNM 647725.

Type locality: 42f (USGS 18836, Barro Colorado Island, northern part of island, stream southeast of Fuertes House, about 335 m above mouth, from slide on west side of stream, Canal Zone), upper part of Bohio formation.

A right and a left valve of the fresh-water genus *Pisidium* were found in the upper part of the Bohio formation on Barro Colorado. My colleague Druid Wilson suggested that these thin-shelled fossils may represent *Pisidium*. In size and outline they are indeed comparable with *P. forbesii* (Philippi, 1869, p. 41; Pfeiffer, 1866–69, p. 489, pl. 105, figs. 15–17, 1869), a species living in high-altitude lakes in Perú and Bolivia, including Lake Titicaca. The fossils, however, are more convex, less inequilateral, and reach a slightly larger size.

At the type locality, *P. atopum* is associated with *Hemisinus, Crassostrea, Anomalocardia,* and five genera of marine mollusks. At locality 42g, the associates are *Neritina* and 13 genera of marine mollusks.

This is the first record of *Pisidium* in the Tertiary Caribbean province.

Occurrence: Upper part of Bohio formation (late Oligocene), localities 42f, 42g.

Family VENERIDAE

Subfamily VENERINAE

Genus Periglypta Jukes-Browne

Jukes-Browne, Malacological Soc. London Proc., v. 11, p. 72, 1914.

Type (orthotype): *Venus puerpera* Linné, living, western Pacific Ocean.

Periglypta tarquinia (Dall)

Plate 103, figure 6

Venus tarquinia Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 5, pl. 38, figs. 2, 2a, 1900 (Miocene, Florida).

Cytherea tarquinia (Dall), Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 6, p. 1274, 1903 (Miocene, Florida).

Antigona tarquinia (Dall), Dall, U. S. Natl. Mus. Bull. 90, p. 147, pl. 26, figs. 1, 2, 1915 (Miocene, Florida). Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 240 (*tarquina* by error), pl. 30, fig. 10, 1922 (Miocene, Costa Rica). Maury, New York Acad. Sci., Scientific Survey Porto Rico and Virgin Islands, v. 3, pt. 1, p. 38, 1920 (Oligocene, Puerto Rico). Mansfield, Florida Dept. Conservation Geol. Bull. 15, p. 264, 1937 (Oligocene(?), Miocene, Florida).

Antigona (Dosina) tarquinia (Dall), Palmer, Palaeontographica Americana, v. 1, no. 5, p. 125, pl. 29, figs. 5, 9 (Dall's illustrations), 1927 (Oligocene, Puerto Rico; Miocene, Florida, Costa Rica).

Antigona caesarina var. *anguillana* Cooke, Carnegie Inst. Washington Pub. 291, p. 150, pl. 16, figs. 4a, 4b, 1919 (Oligocene, Antigua; Miocene, Anguilla).

Antigona (Dosina) caesarina anguillana Cooke, Palmer, Palaeontographica Americana, v. 1, no. 5, p. 126, pl. 29, figs. 2, 3, (Cooke's illustrations), 1927 (Oligocene, Antigua; Miocene, Anguilla).

Of medium size, elliptical-ovate, height slightly less than length, decidedly inequilateral. Strongly convex. Umbo high, wide, full. Posterior end more broadly rounded than anterior. Lunule and escutcheon not exposed. Concentric lamellae low, narrow. Radial riblets between lamellae narrow, closely spaced, slightly frilling lamellae. Interior inaccessible.

Length 48.6 mm, height 41.6 mm, convexity (both valves) 28 mm (figured specimen). Approximate dimensions of largest specimen: length and height 54 mm, convexity (both valves) 32 mm.

Type: USNM 109233.

Type locality: Ballast Point, Tampa Bay, Fla., Tampa limestone.

Seven articulated specimens, from the Emperador limestone member of the La Boca formation, are identified as *Periglypta tarquinia*. They are internal molds but show some sculpture on the molds or on patches of shell. The umbo of these fossils is higher than that of the type, a silicified left valve (length 49 mm), and also higher than that of *P. caesarina anguillana*.

P. caesarina (Dall, 1890–1903, pt. 6, p. 1275, pl. 53, fig. 5, 1903; Chipola formation, Florida) is larger (length 65.5 mm), and its concentric lamellae are wider and noded.

Occurrence: Emperador limestone member of La Boca formation (early Miocene), Gaillard Cut area, localities 117a, 117b, 129a, 129b. Suwannee limestone (late Oligocene), Florida (identification doubtful). San Sebastián formation (late Oligocene), Puerto Rico (Maury's record). Central Plain tuffs (early (?) Oligocene), Antigua. Antigua formation (late Oligocene), Antigua (identication doubtful). Tampa limestone (early Miocene), Florida. Anguilla formation (early Miocene), Anguilla. Deposits of middle Miocene age, Limón Province, Costa Rica (Olsson's record).

Periglypta cf. P. caribbeana (Anderson)

Plate 110, figure 11

Large, vertically ovate, height slightly greater than length, moderately inequilateral. Strongly convex. Part of umbo missing. Posterior margin more strongly rounded than anterior. Concentric lamellae fairly wide and closely spaced where best preserved in small anterior lateral area; elsewhere narrow and more widely spaced, representing their base. No indication of radial riblets. Mold of left anterior and bifid middle cardinal teeth preserved. Right hinge and pallial sinus unknown.

Length (incomplete) 72 mm (estimated restored length 80 mm), height (incomplete) 85 mm (estimated restored height 90 mm), convexity about 35 mm (figured specimen).

The upper member of the Alhajuela formation yielded a right valve of a large venerid. Though it is incomplete and poorly preserved, it appears to be similar to *Periglypta caribbeana* (Anderson, 1927, p. 90, pls. 2, 3), a very large, generally suborbicular and slightly inequilateral species, the type of which has a length of 171 mm.

P. caribbeana occurs in formations of middle and late Miocene age in Colombia (Weisbord, 1929, p. 21, pl. 4, fig. 12), and has been identified in the middle Miocene Cercado formation of the Dominican Republic (*Antigona dominicana* Palmer, 1927, p. 127, 216, pl. 29, figs. 4, 7), and in the late Miocene Limónes formation of the Bocas del Toro Archipelago, Panamá (*Antigona multicostata* [Sowerby), Olsson, 1922, p. 239, pl. 30, fig. 1)].

Occurrence: Upper member of Alhajeula formation (early Miocene), locality 89.

Genus Ventricolaria Keen

Keen, Jour. Paleontology, v. 28, p. 218, 1954.

Type (orthotype): *Venus rigida* Dillwyn, living, Bahamas to Sao Paulo, Brasil.

A very small valve (length 7 mm) from the shallow-water facies of the Caimito formation is listed as *Ventricolaria* sp.

Ventricolaria harrisiana (Olsson)

Plate 100, figures 2, 3, 6

Antigona Harrisiana Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 241 (assigned to section *Ventricola*), pl. 30, fig. 3, 1922 (Miocene, Costa Rica).

Antigona (*Circomphalus*) *harrisiana* Olsson, Palmer, Palaeontographica Americana, v. 1, no. 5, p. 131 (assigned to section *Ventricola*), pl. 30, fig. 6, pl. 31, figs. 1, 3, 1927 (Miocene, Costa Rica, Florida). Haas, Jour. Paleontology, v. 16, p. 308 (list), 1942 (Costa Rica, locality unknown, presumably Miocene).

Antigona palmerae H. K. Hodson, *in* Hodson, Hodson, and Harris, Bull. Am. Paleontology, v. 13, no. 49, p. 58, pl. 31, figs. 6, 7, pl. 35, fig. 8, 1927 (Miocene, Venezuela).

Antigona (*Ventricolaria*) *palmerae* H. K. Hodson, Jung, Bull. Am. Paleontology, v. 49, no. 223, p. 464, pl. 59, figs. 4, 5, 1965 (Miocene, Venezuela).

Of medium size, suborbicular to ovate, height 81 to 96 percent of length, slightly to moderately inequilateral. Strongly convex. Posterior end more broadly rounded than anterior. Umbo high, full. Lunule short, cordate, depressed, circumscribed by narrow groove. Sculpture of low, moderately spaced concentric lamellae (exceptionally lamellae fairly high), and very fine, very closely spaced concentric threadlets in interlamellae. Interior inaccessible.

Length 21.5 mm, height 19.5 mm, convexity 6.25 mm (type, quoted from Olsson). Length 31.3 mm, height 27.4 mm, convexity 9.3 mm (figured right valve sculptured with fairly high lamellae). Length 35.9 mm, height 33.4 mm, convexity about 11 mm (figured suborbicular right valve, largest specimen). Length 33 mm, height 28 mm, convexity about 9 mm (figured ovate left valve).

Type (right valve): Paleontological Research Inst. 21300.

Type locality: Limón, Limón Province, Costa Rica, Limónes formation.

Ventricolaria harrisiana is represented by 70 specimens, from the La Boca formation and one from the lower member of the Alhajuela formation. It is abundant at locality 101h, where 26 specimens were collected, all except eight of which are articulated. These fossils are very variable in outline, ranging from suborbicular to ovate and from slightly to moderately inequilateral. The sculpture also is variable, but that is a matter of preservation. The concentric lamellae of all five specimens from locality 101e, one of which is illustrated (pl. 100, fig. 2), and one from locality 101h are fairly high, presumed to be the original condition. On others, the lamellae are low, and on a few, are even so obliterated that they resemble the fine interlamellar threadlets. The low lamellae and their obliteration are due to preservation as internal molds that retain little shell material or none.

Though the available samples from other localities in the La Boca are meager, they include only suborbicular specimens.

Two incomplete valves from the Chipola formation of Florida were identified by Dall (1890–1903, pt. 6, 1277, 1903) as *V. blandiana* (Guppy), a well-defined more elongate middle Miocene species from the Dominican Republic and Jamaica. Gardner (1926–1947, p. 166, 1926) justly objected to that identification and briefly described them as a doubtful new species. Palmer (1927, p. 131, pl. 31, figs. 1, 3) recorded and illustrated a well-preserved right valve from the Chipola at Baileys Ferry (length 35 mm, height 32 mm, convexity 11 mm), which she identified as *V. harrisiana*—a name that was adopted for the species from the La Boca before her record was noticed. The late Mrs. Shirley E. Hoerle, of West Palm Beach, kindly forwarded four well-preserved valves from the Chipola on Tenmile Creek, the largest of which is slightly larger than Palmer's valve.

V. strigillina (Dall, 1902c, p. 372, 381, pl. 12, fig. 5; living off Florida Keys and also recorded from Barbados and northern Brasil) is a comparable species. It reaches a larger size (length as great as 49 mm), has a larger lunule, and the lamellae of shells from the type region are more closely spaced.

Occurrence: La Boca formation (early Miocene), Gaillard Cut area, localities 99b, 99c, 99d, 99f, 99g, 101e, 101h, 114, 115, 116a. Lower member of Alhajuela formation (early Miocene), locality 82a. Chipola formation (early Miocene), Florida. Cantaure formation (middle Miocene), Falcón, Venezuela. Limónes formation (late Miocene), Limón Province, Costa Rica.

Ventricolaria species

Plate 117, figure 15

Large, trigonal-ovate, height 86 percent of length, moderately inequilateral. Strongly convex. Ventral part of posterior margin missing, producing erroneous impression of almost straight margin. Anterior margin somewhat narrowly rounded. Umbo narrow, high. Shell of large valve greatly corroded, missing on most of anterior and median parts of valve. On posterior part, base of closely spaced concentric lamellae preserved. Elsewhere, shell corroded down to hidden radially striate layer. Fine interlamellar concentric threadlets absent or possibly obliterated. Fine inner denticulations impressed on mold of most of ventral margin. No sculpture preserved in umbonal area. Umbonal fragment of small right valve sculptured with closely spaced concentric lamellae. Lunule cordate, depressed, not clearly circumscribed by groove; escutcheon very narrow. Posterior wedge-shaped cardinal tooth, dorsal part bifid, preserved; anterior and middle cardinal teeth broken back; anterior lateral socket not preserved. Inner margin of lunule not clearly denticulate.

Length (almost complete) 49.7, height 42.7 mm, convexity about 14 mm (figured right valve).

The large corroded valve and the umbonal fragment of an immature valve (length 9 mm, height 7 mm) presumably represent the same species. The two localities are in the same region—cuts on the Panama Railroad south of Gatun, cuts that now are completely soil covered and overgrown.

The outline of the corroded valve is much like that of *Agriopoma gatunensis* (p. 692 of present chapter), with which it is associated. An escutcheon on the right valve is exceptional in the genus. No comparable species, characterized by a narrow high umbo and closely spaced lamellae, has come to my attention. It seems strange that the representation of the genus in the Gatun formation is so meager.

Occurrence: Middle part of Gatun formation (middle Miocene), eastern area, localities 147h, 147i.

Subfamiy CIRCINAE

Genus Gouldia C. B. Adams

C. B. Adams, Catalogue of the genera and species of Recent shells in the collection of C. B. Adams, p. 29 (list and footnote), Middlebury, 1847.

Type (logotype, Dall, Jour. Conchology, v. 4, p. 61, 1883): *Gouldia cerina* (C. B. Adams) (*Thetis cerina* C. B. Adams) living, North Carolina to Alagoas, Brasil.

Gouldia costaricensis (Olsson)

Plate 119, figures 3, 8–10

Gafrarium altum costaricensis Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 234 (asigned to section *Gouldia*), pl. 32, figs. 19, 22, 1922 (Miocene, Costa Rica).

Gafrarium (*Gouldia*) *altum costaricensis* Olsson, Palmer, Palaeontographica Americana, v. 1, no. 5, p. 101, pl. 21, fig. 14, 1927 (Miocene, Costa Rica).

Gafrarium (*Gouldia*) *phacotum* Gardner, U. S. Geol. Survey Prof. Paper 142–D, p. 159, pl. 25, fig. 11, 1926 (Miocene, Florida).

Suborbicular to trigonal-ovate, length and height subequal, subequilateral to decidedly inequilateral, moderately convex. Posterior end slightly more broadly rounded than anterior. Umbo of moderate width, pointed. Lunule narrow, long for size of shell, circumscribed by narrow groove, sculptured with faint growth lines. Immature shells and umbonal area of mature shells generally devoid of sculpture. Sculpture of mature shells variable. Concentric sculpture of regularly spaced rugae on ventral part of valve, or of irregularly spaced growth lines, or a combination of both. Narrow faint radial riblets almost invariably present only on anterior part of valve below umbonal area; exceptionally extending over ventral middle part, and still more exceptionally even on ventral posterior part; exceptionally absent. Hinge of right valve: anterior lateral socket close to anterior cardinal tooth; slender anterior, wider middle, and slender posterior cardinal teeth. Hinge of left valve: anterior lateral tooth close to anterior cardinal tooth; slender anterior, wedge-shaped, obscurely bifid middle, and slender posterior cardinal teeth. Very narrow long groove on inner posterior dorsal margin of right valve and similar shelf on left. Faint groove or grooves on inner ventral margin. Pallial sinus indistinct.

Length 2.8 mm, height 3.1 mm, convexity about 0.8 mm (figured right valve. Length and height 3.1 mm, convexity about 0.8 mm (figured left valve).

Length 3.7 mm, height 3.4 mm, convexity (both valves) 2 mm (largest specimen).

Type material: Lectotype, herewith designated, right-valve syntype illustrated by Olsson (1922) as pl. 2, fig. 22, Paleontological Research Inst. 21339.

Type locality: A small northeastward-flowing stream 3 km southeast of Punta Mona, designated by Olsson as Middle Creek, Limón Province, Costa Rica.

Gouldia costaricensis is locally abundant in the lower part of the Gatun formation, is widespread and locally abundant in the middle part, but is rare in the upper part. About 280 specimens are in the collections, only three of which are articulated. Minute immature valves, down to a length of 1.3 mm, are common. Though almost all are devoid of sculpture, they are recognizable owing to the long lunule and narrow long groove or shelf on the inner posterior dorsal margin. The lectotype and specimens in a suite of six collections from Río Banano agree in size with the fossils from the Gatun, but the remaining syntype is larger (length 4.7 mm).

The type of *G. alta* (Dall, 1890–1903, pt. 6, p. 1249, pl. 57, fig. 5, 1903; Oak Grove sand member of Shoal River formation, Florida) is devoid of sculpture and so are the numerous valves in the type lot, or almost so. The syntypes of *G. phacota* (Shoal River formation) closely resemble specimens from the Gatun.

G. cancellata (Gabb, 1881b, p. 373, pl. 47, fig. 74; Pliocene, Costa Rica; lectotype designated by Palmer, 1927, p. 102, pl. 21, figs. 4, 8, 22) is regarded as a small, convex subspecies of *G. cerina*.

Occurrence: Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, localities 138c, 138e. Middle part, eastern area, localities 139b, 139c, 146, 147b, 147g, 151, 152, 153a, 155a, 155b, 155c, 159d; western area, localities 162, 169. Upper part, eastern area, localities 177b, 177d, 178. Deposits of middle Miocene age, Limón Province, Costa Rica. Shoal River formation proper (middle Miocene), Florida.

Subfamily MERETRICINAE

Genus Cytheriopsis Conrad

Conrad, Am. Jour. Conchology, v. 1, p. 146, 1865.

Type (monotype): *C[ytheriopsis] hydana* (Conrad) (*Cytherea hydana* Conrad), Eocene, Alabama.

Cytheriopsis conradi (Clark)

Plate 85, figure 6

Grateloupia (*Cytheriopsis*) conradi Clark, *in* Clark and Durham, Geol. Soc. America Mem. 16, p. 64, pl. 11, figs. 3–5, 7, 8, 1946 (Eocene, Colombia).

Of medium size, elongate-ovate, height 67 percent of length, moderately inequilateral. Moderately convex. Anterior margin strongly convex, posterior margin slightly convex. Posterior end bluntly pointed. Very shallow posterior depression, slightly insinuating ventral margin. Lunule and sculpture not preserved. Interior unknown.

Length 40.5 mm, height 27.2 mm, convexity about 9 mm (figured right valve).

Type (left valve): Univ. California, Berkeley, 34870.

Type locality: Univ. California, Berkeley, S60, 2 km east of Don Gabriel, in bed of Arroyo Mancomojan, Bolívar Dept., Colombia, late Eocene part of Carmen formation.

Limestone of the Gatuncillo formation in Madden basin yielded a right-valve internal mold. Though the hinge and sculpture are unknown, the outline, especially the bluntly pointed posterior end and the very shallow posterior depression, slightly insinuating the ventral margin, justify assignment to *Cytheriopsis*.

As shown by Clark's illustrations and measurements, in the type region *C. conradi* is variable in outline, even as to which end of inequilateral specimens is more extended. The valve from the Gatuncillo is more similar to the type than to the other specimens illustrated by Clark, although it is more inequilateral than the type.

The posterior margin of the valve from the Gatuncillo is slightly convex, whereas that of *C. hydana* (Palmer, 1927, p. 106, pl. 21, figs. 17, 18, 23, 26, 27) is practically straight. The valve from the Gatuncillo is also more inequilateral and less convex than *C. hydana*, the type species, occurring in the middle Eocene Gosport sand of Alabama.

Occurrence: Gatuncillo formation (late Eocene), locality 6. Late Eocene part of Carmen formation, Bolívar Dept., Colombia.

Genus Tivela Link

Link, Beschreibung der Naturalien-Sammlung der Universität zu Rostock, pt. 3, p. 152, 1807.

Type (logotype, Kobelt, Illustrirtes Conchylienbuch, v. 2, p. 334, 1881): *Cytherea tripla* (Linné) (*Venus tripla* Linné), see Sowerby, Thesaurus conchyliorum, pt. 12, p. 614, pl. 128, figs. 18–22, 1851, living, Mauritania to Angola.

Subgenus Tivela s.s.

Tivela (Tivela) mactroides (Born), small form

Plate 117, figure 12

Of medium size, trigonal-ovate, height slightly less than length, equilateral, convexity strong. Anterior margin slightly concave, posterior margin practically straight. Umbo high, narrow. Lunule elongate, faintly circumscribed by faint groove, or not circumscribed. Sculpture of irregularly spaced growth lines. Hinge of right valve: anterior lateral socket near anterior cardinal tooth, slender anterior and middle, and wedge-shaped bifid posterior cardinal teeth. Hinge of left valve unknown. Pallial sinus indistinct or inaccessible.

Length 30 mm, height 22.3 mm, convexity about 8 mm (figured left valve).

Seventeen specimens from the Culebra and La Boca formations, the lower member of the Alhajuela formation, and the lower and middle parts of the Gatun are identified as a small form of *Tivela mactroides*. With the exception of two from the Gatun, one of which is illustrated, they are internal molds or very small shells.

T. austeniana Maury and its synonym *T. austeniana maturensis* Maury (Jung, 1969, p. 372, pl. 25, figs. 13, 14, pl. 26, figs. 3–6; Pliocene, Trinidad) are very similar to small specimens of *T. mactroides*. Whether the living eastern Pacific *T. byronensis* (Gray) (Olsson, 1961, p. 267, pl. 44, figs. 3, 6–8a) is to be distinguished from *T. mactroides*, at least on the basis of shell features, is doubtful.

Occurrence: Culebra formation (early Miocene), locality 111a, La Boca formation (early Miocene), Gaillard Cut area, localities 99b, 115, 116a. Lower member of Alhajuela formation (early Miocene), locality 79. Lower and middle parts of Gatun formation (middle Miocene); lower part, localities 136, 137, 138c; middle part, western area, localities 161c, 164.

Genus Transennella Dall

Dall, U. S. Natl. Mus. Proc., v. 6, p. 340, 1884.

Type (monotype): *Cytherea (Transennella?) conradina* Dall, living, Palm Beach, Fla. to Florida Keys, and west coast of Florida.

Dall's discussion transformed *Transennella* into a conditional name and therefore makes it available, even though a question mark has to be added to *Transennella* in the orignal name of the type species. (See Article 15, p. 15, of International Code of Zoological Nomenclature, 1961).

Transennella cola Woodring, n. sp.

Plate 117, figure 5

Small, short trigonal-ovate, height slightly less than length, slightly inequilateral. Convexity moderate. Anterior dorsal margin concave at umbo, elsewhere practically straight, posterior dorsal-lateral margin convex. Anterior end more narrowly rounded than posterior. Umbo low, pointed. Lunule narrow, elongate, circumscribed by faint groove. Sculpture of closely spaced rugae at ends of valve, exceptionally extending over median ventral part of valve; remainder of valve bearing growth lines of irregular spacing and strength. Hinge of right valve: anterior lateral socket close to anterior cardinal tooth, slender anterior. bifid middle, and posterior cardinal teeth; hinge of left valve: anterior lateral tooth close to anterior cardinal tooth, slender anterior, bifid middle, and slender posterior cardinal teeth. Inner margin bearing tangential grooves. Pallial sinus moderately deep, apex wide, U-shaped.

Length 4.6 mm, height 4.3 mm, convexity 1.6 mm (type, largest specimen).

Type (left valve): USNM 647646.

Type locality: 159d (USGS 24173, Gatun, Canal Zone, presumably Gatun Locks excavation), middle part of Gatun formation.

The representation of *Transennella* is meager: 10 specimens from the middle part of the Gatun formation. Nevertheless, *T. cola* is the first species of the genus to be described from the Miocene Caribbean province, whereas seven species and an additional subspecies have been recognized in the Miocene of southeastern United States.

T. cola is most similar to *T. caboblanquensis* (Weisbord, 1964, p. 283, pl. 41, figs. 1–8), a small Pliocene species from Venezuela. It is, however, less elongate than the Venezulan species.

Occurrence: Middle part of Gatun formation (middle Miocene), eastern area, localities 146, 159d; western area, locality 166.

Subfamily PITARINAE

Genus Pitar Romer

Römer, Kritische Untersuchung der Arten des Molluskengeschlechts *Venus* bei Linné und Gmelin * * *, p. 15, Marburg, 1857.

Type (monotype): C[*ytherea*] *tumens* Gmel[in], le Pitar Adans[on], living, Mauritania to Cameroon.

Subgenus Pitar s.s.

Pitar (Pitar?) carmenensis Clark

Plate 85, figure 4

Pitar (*Pitar?*) *carmenensis* Clark, *in* Clark and Durham, Geol. Soc. America Mem. 16, p. 67, pl. 10, figs. 2, 3, 1946 (Eocene, Colombia).

Small, ovate, height 80 to 83 percent of length, moderately inequilateral. Strongly convex. Anterior dorsal margin slightly concave; posterior dorsal-lateral margin convex. Posterior end more broadly rounded than anterior. Umbo moderately high, full.

Lunule, as shown by internal molds, narrow, slightly depressed. Sculpture and interior unknown.

Length 23.5 mm, height 18.7 mm, convexity (both valves) 13.3 mm (figured specimen).

Type: California Acad. Sci. 7915.

Type locality: California Acad. Sci., locality 31694, 6 miles (10 km) west of El Carmen, Bolívar Dept., Colombia, late Eocene part of Carmen formation

Six articulated internal molds, collected from limestone of the Gatuncillo formation, are identified as *Pitar carmenensis*. The outline is the chief basis for the generic assignment.

Occurrence: Gatuncillo formation (late Eocene), localities 11, 12. Late Eocene part of Carmen formation, Bolívar Dept., Colombia.

Pitar (Pitar?) yasila (Olsson)

Plate 90, figure 22

Pitaria (*Pitaria*) *yasila* Olsson, Bull. Am. Paleontology, v. 17, no. 62 p. 26, pl. 2, fig. 11, 1930 (Eocene, Perú)

Large, ovate, height 77 percent of length, very inequilateral, umbo at about anterior three-fourth of length. Strongly convex. Anterior dorsal-lateral margin concave at umbo, elsewhere practically straight; posterior dorsal-lateral margin convex. Posterior end more broadly rounded than anterior. Umbo low, broad. Lunule not preserved. Posterior slope somewhat flattened. Sculpture of growth lines, regularly and closely spaced near ventral margin. Interior unknown.

Length 56.5 mm, height 43.6 mm, convexity about 17.5 mm (figured right valve).

Type: Paleontological Research Inst. 24172.

Type locality: Yasila, Piura Dept., Perú, Talara formation.

The illustrated right valve, the only specimen, was collected by Hill at Vamos Vamos in 1895. When it was received, it was labeled *Pitaria* by Dall. Much of the shell is missing or covered by recalcitrant matrix.

As noted by Olsson, this large species is similar in size and general outline to *Pitar angelinae* (Harris) (*in* Van Winkle and Harris, 1919, p. 17, pl. 2, figs. 12, 13), from an undetermined part of the Eocene in Texas. The pallial sinus, impressed on an internal-mold syntype of the Texan species (Harris' fig. 12) is like that of the type species of *Pitar* but is shorter.

Occurrence: Marine rocks of late Eocene age, locality 40a. Talara formation (late Eocene), Perú.

Pitar (Pitar?) dinotus Woodring, n. sp.

Plate 92, figure 1

Small, suborbicular, height about 80 to 89 percent of length, very inequilateral. Moderately convex. Anterior dorsal margin concave at umbo, anterior lateral margin convex; posterior dorsal-lateral margin convex. Posterior end more broadly rounded then anterior. Umbo low, moderately wide. Lunule, as shown by internal molds, narrow, depressed. Sculpture and interior unknown.

Length (practically complete) 31.8 mm, height 28.2 mm, convexity (both valves) 13.7 mm (type).

Type (articulated internal mold): USNM 647651.

Type locality: 62 (USGS 16939, north side of Transisthmian Highway at entrance to plant of Cia. Cemento Panamá, 125 m northwest of Transisthmian Highway bridge across Río Gatuncillo, Panamá), lower part of Quebrancha limestone member of Caimito formation.

Though two articulated internal molds are the only specimens, they are named, inasmuch as suborbicular species of *Pitar* are rare in the Tertiary Caribbean province.

P. dinotus is larger and more inequilateral than *P. euglyptus* (Maury 1925b, p. 329, pl. 17, fig. 7; early Miocene, Brasil) and is smaller and less orbicular than *P. sapotanus* (Olsson, 1932, p. 106, pl. 10, fig. 6; early Miocene, Perú).

Occurrence: Quebrancha limestone member of Caimito formation (late Oligocene), locality 62.

Pitar (Pitar) aff. P. quirosanus (H. K. Hodson)

Plate 98, figure 10

Small to medium size, height 80 to 84 percent of length, moderately inequilateral. Moderately to strongly convex. Anterior dorsal margin concave; posterior dorsal margin slightly convex. Posterior end more broadly rounded than anterior. Umbo low, moderately wide. Lunule not preserved or poorly preserved. Sculpture of low, closely spaced rugae on ventral part of valve, as much as ventral half. Interior inaccessible.

Length 26.5 mm, height 22.3 mm, convexity about 9 mm (figured right valve). Length 38.8 mm, height 31.3 mm, convexity about 12 mm (largest specimen).

Four poorly preserved specimens from the Culebra formation and 18, also poorly preserved, from the La Boca formation, are small or of medium size. They are internal molds, but bits of shell are preserved on a few, and sculpture is imprinted on at least part of the surface of about half of the molds.

These fossils are representatives of a group of small- to medium-sized, moderately inequilateral species of *Pitar* in the Tertiary Caribbean province, ranging in age from late Eocene to early Miocene. The early Tertiary species, one of which (*P. carmensis*) is recorded from the Gatuncillo formation on page 685, have a slightly lower ratio of height to length than do the fossils from the Culebra and the La Boca. The Eocene species of the present account are doubtfully assigned to the subgenus *Pitar* s.s., inasmuch as they may possibly represent the subgenus *Calpitaria*, although the shell outline suggests that is improbable.

The fossils from the Culebra and the La Boca are most similar to *P. quirosanus* (H. K. Hodson, *in* Hodson, Hodson, and Harris, 1927, p. 55, pl. 32, figs. 2, 5). They, however, reach a length 55 percent larger than the Venezuelan species and are sculptured with lirae instead of irregularly spaced growth lines. It has been claimed (Hodson and Hodson, 1931b, p. 7) that *P. quirosanus* is the forerunner of *Macrocallista maculata*, but that view is rejected.

Occurrence: Culebra formation (early Miocene), localities 110a, 112, 112a. La Boca formation (early Miocene), Gaillard Cut area, localities 99a, 99b, 99d, 99h, 115, 119c.

Pitar (Pitar) cf. P. coroanus (H. K. Hodson)

Plate 100, figure 11

Of medium size, ovate, height 81 percent of length, moderately inequilateral. Strongly convex. Anterior dorsal margin slightly concave; posterior dorsal margin practically straight. Posterior and anterior ends about equally rounded. Umbo high, wide. Lunule, as shown by internal mold, narrow, elongate. Sculpture and interior unknown.

Length 37.7 mm, height 30.5 mm, convexity about 12 mm (figured left internal mold).

The upper member of the Alhajuela formation yielded a left-valve internal mold similar in general features to *Pitar coroanus* (H. K. Hodson, *in* Hodson, Hodson and Harris, 1927, p. 57, pl. 33, fig. 7; middle Miocene, Venezuela). The species from the Alhajuela has a higher ratio of height to length than *P. coroanus*.

Two very small, evidently immature specimens of *Pitar* were found in the Chagres sandstone proper at locality 197.

Occurrence: Upper member of Alhajuela formation (early Miocene), locality 85.

Subgenus Hyphantosoma Dall

Dall, U. S. Natl. Mus. Proc., v. 26, p. 354, 1902.

Type (orthotype): *Cytherea carbasea* Guppy, Miocene, Jamaica, Dominican, Republic.

Hyphantosoma is to be added to the list of paciphile subgenera. In western Atlantic waters, its age range is early Oligocene to early Pleistocene. The last known occurrence there is in Olsson's Unit A in Florida (Hoerle, 1970, p. 58). Dall, in his discussion of *Pitar carbaseus*, assigned *P. simpsoni* to *Hyphantosoma* (Dall, 1890–1903, pt. 6, p. 1266, 1903). The type lot of that living species is from Sarasota Bay, Fla. (Dall, 1902a, p. 510, pl. 32, fig. 3). It is a small species of *Pitar s.s.* The Antillean specimens mentioned by Dall have not been found.

Though no records in areas between the Panamic province and New Zealand are known, *Hyphantosoma* occurs in the Miocene of New Zealand (Marwick, 1927, p. 594, figs. 74–76).

Pitar (Hyphantosoma) aff. P. (H.) centangulatus Brown and Pilsbry

Plate 101, figure 7

Two small valves from the Culebra formation and three from the La Boca formation have the outline of immature valves of *Pitar centangulatus*, the next species described. The valves from the Culebra are internal molds, but those from the La Boca are preserved shells. Those from the La Boca at locality 116a retain the fine concentric sculpture on the dorsal half or two-thirds of the shell, like the sculpture of *P. centangulatus*. Moreover, the illustrated specimen shows a patch of faint diagonal radial sculpture on the ventral anterior part.

These fossils, like species from the Culebra or La Boca in some other genera, doubtless represent a small predecessor of *P. centangulatus*.

Length (incomplete) 25.3 mm (estimated restored length 27 mm), height 21.7, convexity about 6.5 mm (figured left valve from the La Boca).

Occurrence: Culebra formation (early Miocene), locality 111b. La Boca formation (early Miocene), Gaillard Cut area, localities 115, 116a.

Pitar (Hyphantosoma) centangulatus Brown and Pilsbry

Plate 122, figures 4–8, 11

Pitar centangulata Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 63, p. 369, 1911 (Miocene, Canal Zone).

Pitaria (*Hyphantosoma*) *centangulata* (Brown and Pilsbry), Palmer, Palaeontographica Americana, v. 1, no. 5, p. 56, pl. 10, figs. 7, 8, 10 (Toula's illustration), 12, 1927 (Miocene, Canal Zone).

Pitaria (*Hyphantosoma* Dall) n. sp., Toula, K. k. Geol. Reichsanstalt Jahrb., v. 58, p. 726, pl. 28, fig. 16, 1909 (Miocene, Canal Zone).

Thin-shelled, generally of medium size, but reaching a fairly large size, trigonal-ovate, height 81 to 87 percent of length, slightly inequilateral to practically equilateral. Strongly convex. Anterior dorsal margin concave; posterior dorsal margin slightly convex to practically straight. Posterior end slightly more broadly rounded than anterior, or both ends about equally rounded. Umbo high, very broad. Lunule cordate, very large for size of shell, circumscribed by narrow groove. Sculpture of low, closely spaced, concentric rugae, exaggerated near ventral margin and undulated by suppressed narrow radial bands. On parts of shell weak, narrow flat bands, arranged in radial zigzag pattern or in incomplete zigzags. On other parts, zigzags replaced by similar radial bands, alined on posterior part of shell like ordinary radial bands, but that alinement continuing on anterior part. Hinge of left valve: elongate lateral tooth some distance from anterior cardinal tooth, and narrow anterior, wedge-shaped middle, and elongate narrow posterior cardinal teeth. Hinge of right valve illustrated by Palmer (1927, pl. 10, fig. 8). Pallial sinus indistinct.

Length 38 mm, height 33.2 mm, convexity (both valves) 24 mm (type). Length 49.5, height (incomplete) 37 mm (estimated restored height 40 mm), convexity about 15 mm (largest specimen in USNM collections).

Type (articulated specimen): Acad. Nat. Sci. Philadelphia 1764.

Type locality: Gatun Locks excavation, Canal Zone, middle part of Gatun formation.

Only 12 specimens of *Pitar centangulatus* are in USNM collections, all from the middle part of the Gatun formation, except a minute fragment from the lower part showing zigzag sculpture (locality 138c). The type is from the middle part and so are three specimens described and illustrated by Palmer, which were collected by Olsson west of Gatun Locks. The only complete USNM valve is somewhat corroded (pl. 122, fig. 7), and the only well-preserved one, which shows to good advantage areas of zigzag sculpture, is nicked (plate 122, fig. 5). The heretofore unillustrated articulated type is shown on plate 122, figs. 4, 8).

The discrepant radial sculpture, shown best on an incomplete right valve (pl. 122, fig. 11), is the only feature to distinguish *P. centangulatus* from *P. carbaseus* (Guppy) (Woodring, 1925, p. 153, pl. 20, figs. 15–19; Miocene, Jamaica). The two species have essentially the same range of variation in outline, and in all species of *Hyphantosoma*, areas of zigzag sculpture are inconstant.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, locality 138c. Middle part, eastern area, localities 139c, 146, 155b; western area, localities 160, 165, 169.

Genus Hysteroconcha Dall

Dall, U. S. Natl. Mus. Proc., v. 26, p. 354, 1902.

Type (orthotype): *Venus dione* Linné, living, West Indies and Bahamas to northern Brasil.

Dall attributed the name *Hysteroconcha* to Fischer. Fischer (1880–1887, p. 1079, 1887), however, cited *Hysteroconcha* Lang, 1722, as a synonym of *Dione* Gray, 1847, which he did not realize was a junior homonym.

Hysteroconcha rosea vanwinkleae (Olsson)

Plate 118, figures 8, 12

Pitaria VanWinkleae Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 238, assigned to section *Lamelliconcha*, pl. 32, figs. 2, 3 1922 (Miocene, Costa Rica).

Pitaria (*Lamelliconcha*) *van winkleae* Olsson, Palmer, Palaeontographica Americana, v. 1, no. 5, p. 54, assigned to section *Hysteroconcha*, pl. 9, fig. 5, 1927 (Miocene, Costa Rica).

Pitaria rosea wiedenmayeri H. K. Hodson, *in* Hodson and Hodson, Bull. Am. Paleontology, v. 16, no. 59, p. 10, assigned to section *Hysteroconcha*, pl. 3, figs. 4, 9, 10, 1931 (Miocene, Venezuela).

Large, ovate, height 82 percent of length, decidedly inequilateral, moderately convex. Anterior dorsal margin concave at umbo; posterior dorsal-lateral margin slightly convex. Anterior end broadly rounded, posterior end narrowly rounded. Umbo low, moderately wide. Lunule small, cordate. Sculpture of concentric lamellae, blunt or upturned. Lamellae greatly worn on almost dorsal half of valve, except near valve margins. Few lamellae slightly extended on posterior subangulation and also on anterior part of valve. Interior inaccessible.

Length 41.5 mm, height 32 mm, convexity 10 mm (type, quoted from Olsson). Length 42.9 mm, height 35 mm, convexity (both valves) 21.4 mm (figured specimen).

Type: Paleontological Research Inst. 21320.

Type locality: Río Banano, Limón Province, Costa Rica, middle Miocene deposits.

Hysteroconcha rosea vanwinkleae—the first record of a spinose species of *Hysteroconcha* in the Miocene Caribbean province—is represented by an articulated specimen, an incomplete specimen, and fragment from the middle part of the Gatun formation. Both Olsson and Hodson realized that the venerid they were dealing with is closely related to the living eastern Pacific *H. rosea* (Broderip and Sowerby) (Olsson, 1961, p. 284, pl. 47, figs. 3–3d). The Caribbean fossils are scarcely distinguishable from the nominate subspecies, which, however, reaches a length of 60 mm, and its lunule is slightly less distinctly circumscribed.

Occurrence: Middle part of Gatun formation (middle Miocene), localities 155, 155c. Middle Miocene deposits, Limón Province, Costa Rica. Late Miocene deposits, Falcón, Venezuela.

Genus Lamelliconcha Dall

Dall, U. S. Natl. Mus. Proc., v. 26, p. 354, 1902.

Type (orthotype): *Cytherea concinna* Sowerby, living, Gulf of California to Paita, Perú.

Lamelliconcha hillii (Dall)

Plate 87, figures 4, 9

Pitaria (*Lamelliconcha*) *Hillii* Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 6, p. 1268, pl. 54, fig. 6, 1903 (Eocene, Canal Zone).

Pitar hillii (Dall), Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 63, p. 370, 1911 (Eocene, Canal Zone, Dall's record).

Pitaria? (*Lamelliconcha*) *hilli* Dall, Palmer, Palaeontographica Americana, v. 1, no. 5, p. 46, pl. 8, fig. 11 (Dalls' illustration). 1927 (Eocene, Canal Zone).

Pitaria (*Lamelliconcha*) *salsola* Olsson, Bull. Am. Paleontology, v. 14, no. 52, p. 39, pl. 8, fig. 7, 1928 (Eocene, Perú).

Of medium size, elongate-ovate, height 60 to 65 percent of length, strongly inequilateral. Moderately convex. Anterior dorsal margin concave; posterior dorsal margin barely convex. Posterior end slightly more broadly rounded than anterior. Umbo low, moderately wide. Lunule small, elongate, slightly depressed. Sculpture of closely spaced concentric rugae. Left middle and long slender posterior cardinal teeth preserved. Right hinge and pallial sinus unknown.

Length (almost complete) 33 mm (estimated restored length 34.5 mm), height 22.5 mm, convexity about 7 mm (lectotype). Length (almost complete) 34 mm (estimated restored length 35.5 mm), height 23 mm, convexity about 7 mm (larger figured specimen, largest specimen).

Type material: Lectotype, herewith designated, right valve illustrated by Dall, USNM 135252.

Type locality: 40a (USGS 2683, Vamos Vamos, a locality off Palenquilla Point submerged by Gatun Lake, marine rocks of late Eocene age.

Twenty-three specimens of *Lamelliconcha hillii*, ranging in length from 7 to an estimated 35.5 mm, are in the collections. Though 17 specimens were collected at the type locality, only the two syntypes are satisfactorily preserved, and they are somewhat corroded. The missing extreme anterior end of the lectotype was restored in the drawing published by Dall.

Owing to Dall's erroneous citation of the type locality as "the vicinity of Gatun," this species has been considered to be a species from the Gatun formation. *L. musanica* (Olsson, 1922, p. 237, pl. 31, fig. 5; middle Miocene, Costa Rica), described as a subspecies of *L. hillii*, has a wider umbo, more pointed posterior end, and cruder sculpture than does the Canal Zone species.

L. salsola closely resembles *L. hillii* in size, outline, and sculpture.

Occurrence: Marine rocks of late Eocene age, localities 40a, 40d, 41 (identification doubtful), 41b, 42, 42a, Samán formation (late Eocene), Perú.

Lamelliconcha cf. L. aequicincta (Spieker)

Plate 103, figure 3

Of medium size to moderately large, ovate, height 76 to 80 percent of length, decidely inequilateral. Moderately convex. Anterior dorsal margin slightly concave; posterior dorsal margin barely convex to practically straight. Umbo low, moderately wide. Lunule small, flattened. Sculpture of concentric rugae of variable width and spacing. Fine, hairlike threads between relatively widely spaced rugae. Interior unknown.

Length (practically complete) 42.3 mm, height 33 mm, convexity about 7 mm (figured left valve, largest specimen).

The La Boca formation yielded nine specimens of *Lamelliconcha* cf. *L. aequicincta*. They range in length from 16 to 42.3 mm. All except the smallest are incomplete. An incomplete left valve from the lower member of the Alhajuela formation may represent the same species.

These fossils are similar to *L. aequicincta* (Spieker, 1922, p. 149, pl. 9, figs. 6, 7; Olsson, 1932, p. 110, pl. 9, fig. 6, pl. 11, figs. 5, 7), from the upper part of the Zorritos formation of Perú, of middle Miocene age. The Peruvian species reaches a larger size (length 50.5 mm) than that of the fossils from the La Boca and its sculpture is less variable.

Occurrence: La Boca formation (early Miocene), Gaillard Cut area, localities 100, 116a, 125. Lower member of Alhajuela formation (early Miocene), locality 82a (identification doubtful).

Lamelliconcha cora (Brown and Pilsbry)

Plate 117, figures 2, 9, 10

Pitar cora Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 63, p. 370, pl. 28, fig. 3, 1911 (Miocene, Canal Zone).

Pitaria (*Lamelliconcha*) *cora* (Brown and Pilsbry), Palmer, Palaeontographica Americana, v. 1, no. 5, p. 47, pl. 8, fig. 8 (Brown and Pilsbry's illustration), 1927 (Miocene, Canal Zone).

Pitaria (*Lamelliconcha*) *circinata* (Born), Dall, Wagner Free Inst. Sci., Trans., v. 3, pt. 6, p. 1269, 1903 (Miocene, Canal Zone).

Pitar circinata (Born), Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 63, p. 370, 1911 (Miocene, Canal Zone, Dall's record).

Pitar (*Lamelliconcha*) *thompsoni* Marks, Bull. Am. Paleontology, v. 33, no. 139, p. 74, pl. 4, figs. 6, 7, 1951 (Miocene, Panamá).

Lamelliconcha thompsoni (Marks), Olsson, Neogene mollusks from northwestern Ecuador, p. 61, pl. 8, fig. 3a, Paleontological Research Inst., 1964 (Miocene, Panamá).

Pitar (*Lamelliconcha*) aff. *P.* (*L.*) *thompsoni* Marks, Marks, Bull. Am. Paleontology, v. 33, no. 139, p. 75, 1951 (Miocene, Ecuador).

Lamelliconcha cf. *thompsoni* Marks, Olsson, Neogene mollusks from northwestern Ecuador, pl. 8, fig. 3a, Paleontological Research Inst., 1964 (Miocene, Ecuador).

Of medium size, ovate, height 75 to 87 (generally 79 to 81) percent of length, moderately to strongly inequilateral. Strongly convex. Anterior lateral margin concave; posterior lateral margin slightly convex. Anterior end broadly rounded, posterior end narrowly rounded. Umbo moderately high, moderately wide. Lunule small, cordate, depressed, sculptured with growth lines. Sculpture of strong, closely spaced upturned concentric lamellae. Hinge of right valve; anterior lateral socket close to anterior cardinal socket; slender anterior and middle, and elongate bifid posterior cardinal teeth. Hinge of left valve: elongate anterior lateral tooth; slender anterior, wedge-shaped middle, and slender, elongate posterior cardinal teeth. Pallial sinus deep, apex rounded.

Length 31.5 mm, height 25 mm, convexity (both valves) 18 mm (type). Length 34 mm, height 25.5 mm, convexity (both valves) 17.7 mm (figured specimen from lower part of Gatun formation).

Type: Acad. Nat. Sci. Philadelphia 1765.

Type locality: Gatun Locks excavation, Canal Zone, middle part of Gatun formation.

Lamelliconcha cora is widespread in the lower and middle parts of the Gatun formation and occurs also in the upper part in the western area: a total of 70 specimens, ranging in length from 2 to 34 mm. Many from the middle part, including the type, are internal molds that show at least some sculpture, or are corroded shells. Pronounced variation in outline, including the degree of inequilaterality is apparent. Minute valves are common; three collections consist only of such specimens.

Olsson suspected that *L. thompsoni* is *L. cora*.

Occurrence: Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, localities 136, 137, 138, 138c, 138d, 138e, 138h. Middle part, eastern area, localities 139, 139g, 141, 143, 144a, 145, 146, 147, 152, 153, 158; western area, localities 160, 161, 161c, 170a. Upper part, western area, localities 182, 182a, Subibaja formation (early Miocene), and Progreso and Angostura formations (middle Miocene), Ecuador.

Genus Macrocallista Meek

Meek, A report on the invertebrate Cretaceous and Tertiary fossils of the upper Missouri country: U.S. Geol. Survey of the Territories (Hayden), Rept. 9, p. 179, 1876.

Type (orthotype): *Venus gigantea* Gmelin (= *Venus nimbosa* [Lightfoot], living, North Carolina to Gulf of Mexico.

Subgenus Paradione Dall

Dall, U. S. Geol. Survey Prof. Paper 59, p. 120, April 2, 1909. Substitute name for *Chionella* Cossmann, 1886, not *Chionella* Swainson, 1840.

Type (logotype of *Chionella* Cossmann, Dall, U.S. Natl. Mus. Proc., v. 26, p. 351, 1902): *Cytherea ovalina* Deshayes, Eocene, Paris basin. *Paradione* was published again by Dall on page 197 of volume 8, of the Proceedings of the Malacological Society of London, which is dated May 7, 1909.

Macrocallista (Paradione) maculata (Linné), small form

Plate 91, figure 9

Small, ovate, height 69 to 71 percent of length, strongly inequilateral. Moderately convex. Anterior dorsal margin slightly convex. Posterior end more narrowly rounded than anterior. Umbo low, narrow. Lunule narrow, elongate, slightly depressed. Sculpture of indistinct growth lines. Interior unknown.

Length 26 mm, height 18.5 mm, convexity about 4 mm (figured right valve from Bohio formation, largest from the Bohio). Length 25.8 mm, height 17.9 mm, convexity about 5 mm (left valve from Caimito formation, only specimen from the Caimito).

A right and a left valve from the upper part of the Bohio formation and a left from the shallow-water facies of the Caimito formation are identified as a small form of *Macrocallista maculata*.

A small form of *M. maculata* also occurs in the Chipola formation of Florida, of early Miocene age (Dall, 1890–1903, pt. 6, p. 1256, 1903). The largest of about 100 specimens in USNM collections has a length of 44 mm.

The meager sample from the Canal Zone extends the range of the species back to late Oligocene time.

Occurrence: Bohio formation (late Oligocene), locality 42d. Shallow-water facies of Caimito formation (late Oligocene), locality 57.

Macrocallista (Paradione) maculata (Linné)

Plate 101, figure 3; plate 117, figure 1; plate 120, figure 11

Venus maculata Linné, Systema naturae, 10th ed., p. 686, 1758 (living, "Oceanus Americano").

Callista maculata (Linné), Gabb, Acad. Nat. Sci. Philadelphia Jour., 2d ser., v. 8, p. 344, 1881 (Miocene, Costa

Rica). Gabb, Acad. Nat. Sci. Philadelphia Jour., 2d ser., v. 8, p. 372, 1881 (Pliocene, Costa Rica). Oinomikado, Geol. Soc. Japan Jour., v. 46, p. 629, 1939 (Miocene, Colombia).

Macrocallista (*Chionella*) *maculata* (Linné), Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 6, p. 1256, 1903 (Miocene to living). Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 73, p. 422, 1922 (Miocene, Dominican Republic). Maury, Bull. Am. Paleontology, v. 10, no. 42, p. 145, pl. 25, figs. 1, 4, 5, 1925 (Miocene, Trinidad). Anderson, California Acad. Sci. Proc., 4th ser., v. 18, no. 4, p. 170, 1929 (Miocene, Colombia).

Macrocallitsa maculata (Linné), Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 234, assigned to section *Chionella*, pl. 31, figs. 6, 7, 1922 (Miocene, Costa Rica). Hodson, Hodson, and Harris, Bull. Am. Paleontology, v. 13, no. 49, p. 54, pl. 32, fig. 6, 1927 (Miocene, Venezuela). Weisbord, Bull. Am. Paleontology, v. 45, no. 204, p. 286, pl. 41, figs. 11–15, pl. 42, figs. 1–6, 1964 (Pliocene, Venezuela; additional citations). Jung, Bull. Am. Paleontology, v. 49, no. 223, p. 460, pl. 58, figs. 4–6, 1965 (Miocene, Venezuela) Jung, Bull. Am. Paleontology, v. 55, no. 247, p. 373, 1969 (Miocene, Trinidad).

Macrocallista (*Paradione*) *maculata* (Linné), Maury, Brasil Serviço Geol. e Mineral. Mon. 4, p. 321, pl. 18, fig. 8, 1925 (Miocene, Brasil). Perrilliat Montoya, Paleontología Mexicana, no. 14, p. 13, pl. 3, figs. 2, 3, 1963 (Miocene, México).

Callista (*Callista*) *maculata* (Linné), Palmer, Palaeontographica Americana, v. 1, no. 5, p. 78, pl. 10, fig. 11, pl. 12, figs. 1–3, 8, 9, pl. 14, fig. 4, 1927 (Miocene to living).

Macrocallista maculata (Linné)?, Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 62, p. 370, 1911 (Miocene, Canal Zone; Conrad's record).

Meretrix dariena Conrad, Appendix to the preliminary geological report of William P. Blake: U.S. 33d Cong., 1st Sess., House Doc. 129, p. 18, 1855; reprint Dall, U.S. Geol. Survey Prof. Paper 59, p. 170, 1909 (Miocene, Canal Zone).

Cytherea? (*Meretrix*) *Dariena* (Conrad)?, Conrad, U. S. Pacific R. R. Explor., v. 6, Geol. Rept., p. 72, pl. 5, fig. 21, 1857; reprint Dall, U.S. Geol. Survey Prof. Paper 59, p. 178, 1909 (Miocene, Canal Zone). Not *Meretrix dariena* Conrad, U.S. Pacific R. R. Explor., v. 5, Geol. Rept., Appendix, Art, 2, p. 328, pl. 6, fig. 55, 1856 (Miocene, Canal Zone).

Callista (*Callista*) cf. *albaria* (Say), Barrios, Colombia Servicio Geol. Nac., Bol. Geol., v. 6, nos. 1–3 (Informe 1082), p. 253, pl. 5, fig. 10, 1960 (Miocene, Colombia).

The preceding synonymy is designed to cover occurrences in the Tertiary Caribbean province. An elaborate synonymy was published by Weisbord (1964).

Moderately large, ovate, height 68 to 81 (generally 70 to 80) percent of length, moderately inequilateral. Moderately convex. Anterior dorsal margin concave near umbo; posterior dorsal-lateral margin slightly convex. Posterior end more narrowly rounded than anterior. Posterior slope generally smoothly rounded; exceptionally abruptly rounded. Umbo low, wide. Lunule narrow, elongate, slightly depressed, umbonal part generally circumscribed by faint groove. Sculpture of irregularly spaced growth lines, emphasized on slightly corroded valves. Hinge typically pitarine. Proximal part of face of nymph vertically striate on immature and some mature valves. Pallial sinus moderately deep, apex at lower limb, angular.

Length 48.6 mm, height 34.5 mm, convexity 13 mm (figured right valve from Gatun formation, posterior slope smoothly rounded). Length 53 mm, height 37 mm, convexity (both valves) 19.6 mm (largest specimen, Gatun formation).

Type: Museum of Linnean Society of London.

Type locality: West Indies.

The occurrence of *Macrocallista maculata* in the faunas under consideration, the number of specimens, the largest specimen, and the condition of the fossils are tabulated as follows:

Occurrence of Macrocallista maculata

Age			Formation		Number of specimens	Length, in mm, of largest specimen	Condition
Miocene or Pliocene	Late Miocene or early Pliocene		Toro limestone member of Chagres Sandstone.		4	[3] 50	Internal molds.
Miocene	Middle		Gatun	Upper part, western area.	10	53	Mostly shells.
				Upper part, eastern area.	1		
				Middle part	63		
				Lower part	270		
	Early	Late	Alhajuela	Upper member.	11	[3] 60	Internal molds.
				Lower member.	3	[3] 35	Do.
		Early		La Boca	[1] 55	47.7	Mostly internal molds.
				Culebra	5	39.7	Shells and internal molds.
Oligocene	Late			Caimito	[2] 1	25.8	Shell.
				Bohio	[2] 4	26	Mostly internal molds.

[1] Includes small internal mold from Emperador limestone member (length 35.5 mm).

[2] Small form.

[3] Estimated.

An almost steady increase in size with decreasing age is apparent. The numerous specimens from the lower part of the Gatun include minute shells, the length of which is as small as 1.7 mm. Shells that have an abruptly rounded posterior slope, like some from the Gatun (pl. 120, fig. 11), were not observed among living specimens. In the Caribbean region, this species occurs at almost every locality where mollusks of early Miocene to Pliocene age have been found.

Occurrence: Culebra formation (early Miocene), localities 106, 111b, 112. La Boca formation (early Miocene), Gaillard Cut area, localities 99c, 99d, 99g, 99h, 101h, 114, 115a, 115b, 116a, 119, 119a, 119c. Emperador limestone member of La Boca formation (early Miocene), Madden basin, locality 71. Lower member of Alhajuela formation (early Miocene), localities 79 (cf), 82a. Upper member of Alhajuela formation (early Miocene), localities 85, 85a, 90a. Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, localities 136, 136a, 137, 138, 138b, 138c, 138d, 138e, 138f, 138g, 138h. Middle part, eastern area, localities 139, 139b, 139c, 139e, 139f, 139g, 143, 147g, 155, 157, 159b; western area, localities 160, 161, 161a, 164, 166. Upper part, eastern area, locality 173; western area, localities 180, 182, 182a, 185. Toro limestone member of Chagres sandstone (late Miocene or early Pliocene), localities 193, 196. Pirabas formation (early Miocene), Brasil. Miocene, presumably middle Miocene, Dominican Republic (Pilsbry's record). Agueguexquite formation (middle Miocene), Tehuantepec area, México. Middle Miocene deposits, Limón Province, Costa Rica. Tubará formation (middle Miocene), Atlántico Dept., Colombia. Cantaure formation (middle Miocene), Falcón, Venezuela. La Vela formation (late Miocene), Falcón, Venezuela. Limónes formation (late Miocene), Limón Province, Costa Rica, and Bocas del Toro area, Panamá (USGS 8412, 8345). Savaneta glauconitic sandstone member and Melajo clay member of Springvale formation (late Miocene), Trinidad. Catia and Maiquetia members of Playa Grande formation, and Mare formation (early Pliocene), Distrito Federal, Venezuela. Cumaná formation (early Pliocene), Sucre, Venezuela. Living, North Carolina and Bermuda to Santa Catarina, Brasil.

Genus Costacallista Palmer

Palmer, Palaeontographica Americana, v. 1, no. 5, p. 84, 1927.

Type (orthotype): *Callista erycina* (Linné) *Venus erycina* Linné), living, western Pacific Ocean.

When *Costacallista* was proposed, it was thought that the genus was no longer living in western Atlantic waters. Later, *Cytherea eucymata* Dall, ranging from North Carolina to northern Brasil, was found to be a species of *Costacallista* (Palmer, 1947).

Costacallista gabrielensis (Clark)

Plate 90, figure 17

Macrocallista (*Costacallista*) *gabrielensis* Clark, *in* Clark and Durham, Geol. Soc. America Mem. 16, p. 65, pl. 11, figs. 1, 2, 11, 12, 13, 1946 (Eocene, Colombia).

Macrocallista (*Costacallista*) *masinguiensis* Clark, *in* Clark and Durham, Geol. Soc. America Mem. 16, p. 66, pl. 8, figs. 7, 8, 1946 (Eocene, Colombia).

Of medium size, broadly ovate, height 75 to 81 percent of length, very inequilateral. Moderately convex. Anterior dorsal margin concave; posterior dorsal-lateral margin slightly convex. Posterior end more narrowly rounded than anterior. Umbo low, wide. Lunule narrow, elongate, slightly depressed, circumscribed by faint groove. Sculpture of narrow flat concentric bands, separated by striae. Bands bearing hidden fine radial threadlets, shown on slightly corroded areas. Interior unknown.

Length (practically complete) 42.5 mm, height (practically complete) 34.5 mm, convexity about 9 mm (figured left valve, largest specimen).

Type of *Costacallista gabrielensis* (right valve): Univ. Calif. Berkeley, 34895; type of *C. masinguiensis* (right valve): Univ. Calif. Berkeley, 34898.

Type locality of *C. gabrielensis*: Univ. Calif. Berkeley, locality 560, Don Gabriel-Pijiguay trail crossing of Mancomoján anticline, 2 km east of Don Gabriel, in bed of Arroyo Mancomoján, Bolívar Dept., Colombia, late Eocene part of Carmen formation. Type locality of *C. masinguiensis*: Univ. Calif. Berkeley, locality S7333, north branch of Arroyo Masingui, about 0.8 km southeast of Loma del Viento, Bolívar Dept., Colombia, late Eocene part of Carmen formation.

C. gabrielensis is represented by 32 specimens from the marine rocks of late Eocene age, ranging in length from 3.7 to 42.5 mm. Most specimens are in poor condition. The illustrated valve is from locality 40a, one of Hill's Vamos Vamos collections, which yielded the type of *Lamelliconcha hillii*. As noted under that species (p. 688 of present account), Dall erroneously assigned that collection to the "Gatun beds."

These fossils from the Canal Zone are somewhat variable in the ratio of height to length. In the type regions, *C. gabrielensis* is more variable, not only in that ratio, but also in the degree of inequilaterality.

C. gabrielensis is closely related to *C. mortoni* (Conrad) (Palmer, 1927, p. 88, pl. 15, figs. 11, 19, 20; middle Eocene, Alabama), which reaches a larger size (length 50 mm) and has a slightly lower ratio of height to length.

Occurrence: Marine rocks of late Eocene age, localities 40a, 40d, 41, 41a, 41b, 42, 42a. Late Eocene part of Carmen formation, Bolívar Dept., Colombia.

Costacallista leiotera Woodring, n. sp.

Plate 119, figures 11, 14

Of medium size, ovate, height 69 to 75 (generally 72 to 75) percent of length, strongly inequilateral. Moderately convex. Anterior dorsal margin concave at umbo; posterior dorsal-lateral margin slightly convex. Posterior end more narrowly rounded than anterior. Umbo low, wide. Lunule narrow, elongate, slightly depressed, circumscribed by faint groove. Umbonal part sculptured with narrow flat concentric bands, separated by striae. Remainder of shell bearing irregularly spaced growth lines. Hidden, faint, fine concentric threadlets in corroded areas. Hinge typically pitarine. Pallial sinus indistinct.

Length 43 mm, height 30.8 mm, convexity 12 mm (type).

Type (right valve): USNM 647700.

Type locality: 159d (USGS 24173 Gatun, presumably Locks excavation, Canal Zone), middle part of Gatun formation.

Costacallista leiotera was found at two localities in the middle part of the Gatun formation: 25 valves, including 12 of minute size, down to a length of 2.4 mm. The umbonal sculpture is shown to best advantage on minute valves, such as that on plate 119, figure 14).

This is the first record, in the Tertiary Caribbean province, of a species of *Costacallista* that is sculptured only in the umbonal area.

Occurrence: Middle part of Gatun formation (middle Miocene), eastern area, locality 159d; western area, locality 169.

Genus Agriopoma Dall

Dall, U.S. Natl. Mus. Proc., v. 24, p. 509, 1902.

Type (logotype, Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 6, p. 1259, 1903); *Cytherea texasiana* Dall, living, Gulf of Mexico.

Subgenus Pitarella Palmer

Palmer, Palaeontographica Americana, v. 1, no. 5, p. 35, 1927.

Type (orthotype): *Pitaria gatunensis* (Dall) [*Callocardia* (*Agriopoma*) *gatunensis* Dall], Miocene, Canal Zone.

The close relationship of *Agriopoma* and *Pitarella* was implied by Dall when he named the type species of *Pitarella*. It was discussed by Palmer, and was formalized by Olsson (1961, p. 278), who treated *Pitarella* as a subgenus of *Agriopoma*, a classification adopted in the present account.

The Peruvian *Agripoma mancorensis* (Olsson, 1931, p. 56, pl. 7, figs. 2, 5) and a small form from the Santiago area of southwestern Panamá, listed and illustrated by Joukowsky (1906, p. 163, pl. 6, fig. 19) as *Callocardia* (*Agriopoma*) *gatunensis* Dall, probably are the earliest species of *Pitarella*. Both are of late Oligocene age, and the hinge of both is unknown. The subgenus was widely distributed in the Miocene Caribbean province: Jamaica, the Dominican Republic, southeastern Costa Rica, the Canal Zone, Darién, Colombia, Venezuela, Trinidad, Ecuador, and Perú, and also Florida. *Pitarella* is now extinct in the western Atlantic Ocean, but, as noted under the type species, survives in the eastern Pacific Panamic province.

As Rehder and Abbott realized, their *Pitarenus* (Rehder and Abbott, 1951, p. 57; type (orthotype): *Pitaria cordata* Schwengel, living, Gulf of Mexico) is closely related to *Pitarella*, with the notable exception that the inner margin is finely denticulate, a remarkable feature for a pitarine venerid, indicating a different shell structure. Like *Pitarella*, *Pitarenus* is better treated as a subgenus of *Agriopoma*, rather than as subgenus of *Pitar*.

Agriopoma (*Pitarella*) *gatunensis* (Dall)

Plate 118, figures 1, 3–7

Callocardia (*Agriopoma*) *gatunensis* Dall, Wagner Free Inst. Sci. Trans., v. 3. pt. 6, p. 1260, pl. 54, fig. 1, 1903 (Miocene, Canal Zone). Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 63, p. 370, 1911 (Miocene, Canal Zone, Dall's record). Maury, Bull Am. Paleontology, v. 10, no. 42, p. 146, pl. 27, figs. 5, 7, 1925 (Miocene, Trinidad). Anderson, California Acad. Sci. Proc., 4th ser., v. 18, no. 4, p. 168, 1929 (Miocene, Colombia).

Callocardia gatunensis Dall, Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 235 (assigned to subgenus *Agriopoma*), pl. 32, fig. 1, 1917 (Miocene, Costa Rica).

Pitaria (*Pitarella*) *gatunensis* (Dall), Palmer, Palaeontographica Americana, v. 1, no. 5, p. 35, pl. 7, figs. 3, 7, 9, 10 (Dall's illustration), pl. 9, figs. 3, 9, 1927 (Miocene, Canal Zone, Costa Rica).

?*Callocardia* (*Agriopoma*) *gatunensis* Dall, Joukowsky, Soc. Phys. Hist. Nat. Genève Mém., v. 35, p. 163 (list), pl. 6, fig. 19, 1906 (Oligocene, Panamá).

Callocardia? cf. *C. gatunensis* Dall, Toula, K. k. Geol. Reichsanstalt Jahrb., v. 58, p. 723, pl. 25, fig. 23, 1909 (Miocene, Canal Zone).

Callocardia (*gatunensis* variety) *multifilosa* Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 6, p. 1261, pl. 54, fig. 15, 1903 (Miocene, Canal Zone).

Callocardia gatunensis multifilosa Dall, Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 63, p. 370, 1911 (Miocene, Canal Zone, Dall's record). Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 64, p. 502 (list), 1913 (Miocene, Canal Zone).

Pitaria (*Pitarella*) *gatunensis multifilosa* (Dall), Palmer, Palaeontographica Americana, v. 1, no. 5, p. 36, pl. 7, fig. 6 (Dall's illustration), 1927 (Miocene, Canal Zone). Marks, Bull. Am. Paleontology, v. 33, no. 139, p. 75, pl. 5, fig. 2, 1951 (Miocene, Ecuador).

?*Isocardia* sp. (aff. *Isocardia cor* L., juv.) Toula K. k. Geol. Reichsanstalt Jahrb., v. 58, p. 722, pl. 27, fig. 7, 1909 (Miocene, Canal Zone).

Callocardia? sp. Toula, K. k. Geol. Reichsanstalt Jahrb., v. 58, p. 723, 1909 (Miocene, Canal Zone).

Cytherea (*Callista, Meretrix*) aff. *rudis* Poli, Toula, K. k. Geol. Reichsanstalt Jahrb., v. 61, p. 495, pl. 31, fig. 5, 1911 (Miocene, Canal Zone).

Large, ovate, height 72 to 84 (generally 78 to 84) percent of length), decidedly inequilateral. Convexity strong. Lunule not depressed, circumscribed by faint groove, not interrupting sculpture. Umbo high, full, incurved. Anterior dorsal margin practically straight to slightly concave; posterior dorsal-lateral margin convex. Posterior end more broadly rounded than anterior. Sculpture faint or absent in umbonal area, probably due to wear; elsewhere variable, ranging from irregularly though closely spaced growth lines to more or less regularly and closely spaced narrow flat threads (*multifilosa* type of sculpture). Hinge of right valve: anterior lateral socket adjoining anterior cardinal tooth, narrow anterior, slender triangular middle, and wedge-shaped bifid posterior cardinal teeth; anterior and posterior joined, forming bridge. Hinge of left valve: peg-shaped or transversely elongate anterior lateral tooth, adjoining socket for right anterior cardinal tooth, massive wedge-shaped middle, and slender elongate posterior cardinal teeth; anterior and middle joined, forming bridge. Pallial sinus short, apex narrow.

Length (incomplete) 36 mm (estimated restored length 38 mm), height 30.5 mm, convexity about 12 mm (type of *A. gatunensis*). Length 38.7 mm, height 33.5 mm, convexity about 11 mm (type of *A. gatunensis multifilosa*). Length 57.6 mm, height 45.7 mm, convexity (both valves) 28 mm (largest specimen).

Type of *A. gatunensis* (left valve): USNM 135249; type of *A. gatunensis multifilosa* (right valve): USNM 6392a.

Type locality of *A. gatunensis*: 158 (USGS 2682, alleged to be Vamos Vamos, Canal Zone, error for near Gatun, Canal Zone), middle part of Gatun formation. Type locality of *A. gatunensis multifilosa*: 177f, alleged to be Ponton, Dominican Republic, error for Monkey Hill (now Mount Hope), Canal Zone, upper part of Gatun formation.

Agriopoma gatunensis occurs throughout the Gatun formation and at many localities in the middle part; in the upper part in the eastern area it is common or abundant. An estimated 200 specimens are available. Many are articulated; in fact, at almost half the localities in the middle part, and in the upper part in the eastern area, all are articulated. Immature specimens, reaching a minimum length of 0.9 mm, are common, especially at localities 139b, 139c, 155c, and 162.

As shown by the illustrations, in the Gatun the species reaches a considerably larger size than Dall's types. Variation affects the outline and sculpture. The *multifilosa* type of sculpture is not confined to the upper part of the Gatun.

Dall's description of the right hinge and pallial sinus was based on two specimens from the alleged Ponton, Dominican Republic, collection, now entered as locality 177f. His record of the occurrence at Claremont, St. Ann Parish, Jamaica, surely is an error. This is a middle or late Eocene locality in the White limestone group—the type locality of *Pseudomiltha megameris* (p. 620 of present chapter).

The left-valve type of *A. calceola* (Gardner, 1936, p. 30, pl. 7, figs. 3, 4; Shoal River formation), the only known specimen of *Pitarella* from Florida, has a more extended anterior end than *P. gatunensis*. On the basis of external features, it is practically indistinguishable from large articulated specimens of *A. paraguanensis*, as identified by Jung (1965, p. 461, pl. 58, fig. 7; Miocene, Venezuela), although the type of *A. paraguanensis* (H. K. Hodson, *in* Hodson, Hodson, and Harris, 1927, p. 56, pl. 33, fig. 1) resembles *A. gatunensis*.

Some specimens of *A. gatunensis* are as inequilateral as *A. tumbezana* (Olsson, 1932, p. 107, pl. 10, figs. 1, 3; Miocene, Perú). The weak sculpture of the Peruvian fossils is a matter of preservation.

Though no comparable species is known to be living in western Atlantic waters, *A. gatunensis* is very similar to *A. catharia* (Dall, 1902c, p. 387, 402, pl. 14, fig. 3), which ranges from Baja California to Ecuador. As noted by Dall, the apex of the pallial sinus of immature specimens of the living species is narrow, whereas on mature specimens it is wide. Only two of the fossils from the Gatun, both mature, show the sinus; the apex of both is narrow.

It has been indicated that *Callocardia ammondea* (Woodring, 1925, p. 151, pl. 20, figs. 11, 12) and *C. elethusa* (Woodring, 1925, p. 152, pl. 20, figs. 13, 14), two alleged species from Bowden, Jamaica, are to be suppressed as synonyms of *Agriopoma gatunensis* (Woodring, 1928, p. 21, footnote). Since that was written, two somewhat larger specimens from the Aldrich collection have become available (length of larger 23.1 mm). In view of the small size of this species of *Pitarella*, the fossils from Bowden are now identified as *A. tryoniana* (Gabb)? (Pilsbry, 1922, p. 422, pl. 47, fig. 11; Miocene, Dominican Republic, length 28 mm), which was described by Maury (1917, p. 216, pl. 37, fig. 10, length 30 mm). The type of *Callocardia guttata* A. Adams, the Korean monotype of *Callocardia* (Arthur Adams, 1864, p. 307) was illustrated by Palmer (1927, p. 38, pl. 7, figs. 1, 4, 11). It is a so-called vesicomyid.

Occurrence: Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, localities 138, 138c, 138e, 138h. Middle part, eastern area, localities 139, 139b, 139c, 139d, 139e, 139g, 139h, 140, 142, 143, 145, 146, 147, 147a, 147b, 147f, 147g, 147h, 149g, 150a, 151, 153, 155, 155a, 155b, 155c, 157, 158, 159; western area, localities 160, 160a, 160d, 161, 161a, 162, 162a, 168. Upper part, eastern area, localities 163, 172, 173a, 174, 175, 176, 176a, 177, 177b, 177c, 177e, 177f, 178; western area, localities 183, 185. Deposits of middle Miocene age, Limón Province, Costa Rica; Darién, Panamá (USGS 8430, 8477). Tubará formation, Atlántico Dept., Colombia (Anderson's record). Machapoorie limestone member and Brasso formation proper (middle Miocene), Trinidad (Maury's record). Daule formation (middle Miocene, Ecuador (Marks' record). Limónes formation (late Miocene), Bocas del Toro area, Panamá (USGS 8498).

Subfamily DOSININAE

Genus Dosinia Scopoli

Scopoli, Introductio ad historiam naturalem * * *, p. 3999, Prague, 1777.

Type (monotype): Le dosin Adanson, his 5th species arranged under the genus *Chama* (=*Venus concentrica* Born), living, West Indies to Santa Catarina, Brasil.

According to Fischer-Piette (1942, p. 308, pl. 14, fig. 4), the specimen he illustrated and identified as *Dosinia concentrica* may have served as Adanson's illustration of le dosin (pl. 16, fig. 5). Dall (1902c, p. 346) thought that le dosin is *D. africana* (Hanley); that is, *D. africana* (Gray) (1838, p. 309). Hanley (1842–56, p. 107, pl. 15, fig. 40, 1844) repeated Gray's description and added an illustration. According to the reduction specified for Hanley's illustration, the largest valve in a collection of 12 (length 17 mm), collected at Cape Palmas, Liberia (USNM 15035), has about the same dimensions. As Fischer-Piette realized, his identification has the effect of converting *Dosinidia* Dall (1902c, p. 347, type (orthotype): *Venus concentrica* Born) into an objective junior synonym of *Dosinia* s.s.

Small internal molds from the Quebrancha limestone member of the Caimito formation are listed as *Dosinia*? sp., and small valves from the Culebra formation and the Toro limestone member of the Chagres sandstone, as *Dosinia* sp.

Subgenus Dosinia s.s.

Dosinia (Dosinia) aff. D. delicatissima Brown and Pilsbry

Plate 91, figure 26

Of medium size, thin-shelled, suborbicular, height slightly less than length, moderately inequilateral. Moderately convex. As usual, anterior dorsal margin concave; posterior dorsal-lateral margin convex. Umbo low, moderately wide. Lunule not preserved, but according to impression, narrowly cordate and deeply depressed. Sculpture of flat, very narrow concentric bands, separated by striae. Interior inaccessible.

Length 45.7 mm, height 41.5 mm, convexity about 7 mm (figured right valve). Length 52.5 mm, height 50 mm, convexity about 7 mm (largest specimen).

Nine valves from the upper part of the Bohio formation of Barro Colorado Island, ranging in length from 33 to 52.5 mm, doubtless represent a predecessor of *Dosinia delicatissima*, the next species. They are distinguished from that species by the narrow width of the concentric bands on the entire shell.

Occurrence: Bohio formation (late Oligocene), locality 42d.

Dosinia (Dosinia) delicatissima Brown and Pilsbry

Plate 102, figure 2; plate 118, figures 9, 14

Dosinia delicatissima Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 64, p. 516, pl. 26, fig. 1, 1913 (Miocene, Canal Zone). Palmer, Palaeontographica Americana, v. 1, no. 5, p. 63 (assigned to section *Dosinidea*), pl. 17, figs. 1 (Brown and Pilsbry's illustration), 9, 1927 (Miocene, Canal Zone). Anderson, California Acad. Sci. Proc., 4th ser., v. 18, no. 4, p. 166, 1929 (Miocene, Colombia).

Dosinia (*Dosinidia*) *delicatissima* Brown and Pilsbry, Spieker, Johns Hopkins Univ., Studies Geology, no. 3, p. 140, 1922 (Miocene, Perú). Olsson, Bull. Am. Paleontology, v. 19, no. 68, p. 103, pl. 9, figs. 3–5, 1932 (Miocene, Perú, Ecuador). Marks, Bull. Am. Paleontology, v. 33, no. 139, p. 72, 1951 (Miocene, Ecuador).

Dosinia acetabulum (Conrad), Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 231 (assigned to section *Dosinidea*), pl. 31, fig. 1, 1922 (Miocene, Costa Rica, Canal Zone). Palmer, Palaeontographica Americana, v. 1, no. 5, p. 63 (assigned to section *Dosinidea*), 1927 (part, Miocene, Costa Rica, Canal Zone).

Dosinia (*Artemis*) cf. *acetabulum* Conrad, Toula, K. k. Geol. Reichsanstalt Jahrb., v. 58, p. 727, pl. 27, figs. 8, 8a, 1909 (Miocene, Canal Zone).

Dosinia (*Artemis*) *acetabulum* Conrad?, Anderson, California Acad. Sci. Proc., 4th ser., v. 18, no. 4, p. 166, 1929 (Miocene, Colombia).

?*Dosinia brasiliensis* White, Mus. Nac. Rio de Janeiro Archivos, v. 7, p. 97, pl. 8, figs. 13–15, 1887 (Miocene, Brasil).

?*Dosinia* (*Dosinidea*) *brasiliensis* White, Maury, Brasil Serviçio Geol. e Mineral. Mon. 4, p. 319, pl. 17, fig. 17, 1925 (Miocene, Brasil).

Of medium size to moderately large, thin-shelled, suborbicular, height slightly less than length to slightly more (slightly less more common than slightly more). Moderately inequilateral, convexity fairly strong. Umbo moderately high, wide. Lunule narrowly cordate, deeply depressed, more or less circumscribed by faint groove. Sculpture of flat concentric bands, separated by striae. Bands very narrow in umbonal area, with few exceptions increasing in width on ventral half of valve to fairly wide; exceptionally suppressed on about ventral third. Left anterior lateral tooth small or pustular, close to anterior cardinal tooth; right anterior lateral socket comparable in size and location. Left middle cardinal tooth wide, wedge-shaped. Right posterior cardinal tooth bifid. Pallial sinus indistinct.

Length 44 mm, height 43.2 mm, convexity (both valves) 20 mm (figured specimen from La Boca formation). Length 48 mm, height 46 mm, convexity about 11 mm (type, from Gatun formation). Length (almost complete 65 mm (estimated restored length 67 mm), height (almost complete) 61.7 mm (estimated restored height 64 mm), convexity 16 mm (figured valve from upper part of Gatun formation in western area, largest specimen from the Gatun).

Type (right valve): Acad. Nat. Sci. Philadelphia 3885.

Type locality: Spillway of Gatun Dam, Canal Zone, middle part of Gatun formation.

The occurrence of the 75 specimens of *Dosinia delicatissima* and of the nine valves of its presumed predecessor is shown in the following table.

Occurrence of Dosinia delicatissima

Age		Formation		Number of specimens	Length, in mm, of largest specimen
Miocene	Middle	Gatun	Upper part, western area	6	[1] 67
			Upper part, eastern area	--	--
			Middle part	40	[1] 58
			Lower part	1	37
	Early	Upper member of Alhajuela.		3	[1] 50
		La Boca		[2] 25	55.5
Oligocene	Late	Bohio		[3] 9	52.5

[1] Estimated.

[2] Includes a valve from Emperador limestone member in Madden basin (estimated restored length 49 mm).

[3] Described as *D.* aff. *D. delicatissima*.

Disregarding the single immature specimen from the lower part of the Gatun and the incomplete specimens from the upper member of the Alhajuela formation, a slight increase in size with decreasing age is apparent, but specimens in the upper part of the Gatun in the western area show a decided increase in size.

Brown and Pilsbry (1913) recorded this species from the La Boca formation (that is, in the tower N area in the Las Cascadas Reach), as well as in the Gatun. Its absence in the upper part of the Gatun in the eastern area is noteworthy. Articulated specimens are common—40 percent of those tabulated. Minute valves, ranging in length from 1.8 to 4 mm are uncommon, but the only specimens from localities 147g and 159b are minute. Despite their size (length of larger is 42 mm) the sculpture throughout on two valves from locality 155b is like that of *D.* aff. *D. delicatissima* from the Bohio.

D. acetabulum (Conrad) (Palmer, 1927, p. 63, pl. 19, figs. 1–3, 5–7, 9), which occurs in the Chesapeake group of Maryland and Virginia, has a thicker shell than *D. delicatissima*, reaches a larger size (length as great as 80 or even 100 mm), and its sculpture tends to be finer. The concentric bands of the type of *D. liogona* (Dall, 1890–1903, pt. 6, p. 1230, pl. 57, fig. 11, 1903; length 48 mm), from the Oak Grove sand member of the Shoal River formation of Florida, are slightly wider than those of *D. delicatissima*. Dall identified as *D. liogona* minute valves represented by thousands of specimens in the collection that yielded the type and fragments, and he illustrated two of them on his plate 53, figures 4, 7. The striations, however, are on the inner face of the nymph, not on the posterior cardinal tooth, as described by Dall.

Occurrence: La Boca formation (early Miocene), Gaillard Cut area, localities 99a, 99c, 99g, 101h, 119, 119a, 119b, 119c, 120a. Emperador limestone member of La Boca formation (early Miocene), Madden basin, localities 71, 73 (sp.). Upper member of Alhajuela formation (early Miocene), locality 89. Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, locality 138e. Middle part, eastern area, localities 141, 143, 144, 144a, 145, 147g, 150, 155b, 159b, 159d; western area 160, 160d, 161, 161c, 162, 164. Upper part, western area, localities 182, 182a, 185. Deposits of early Miocene age, Río Sinú area, Córdoba Dept., Colombia (USGS 11613 and other collections). Pirabas formation (early Miocene), Brasil (identification doubtful). Lower part of Zorritos formation (early Miocene), Perú. Subibaja formation (early Miocene), Ecuador. Deposits of middle Miocene age in Limón Province, Costa Rica. Tubará formation (middle Miocene), Atlántico Dept., Colombia. Progreso formation (middle Miocene), Ecuador. Limónes formation (late Miocene), Limón Province, Costa Rica, and Bocas del Toro area, Panamá (USGS 8412 and 8345, respectively).

Dosinia (Dosinia) aff. D. ponderosa titan Maury

Plate 103, figure 2

Large, suborbicular, height slightly less than length to moderately less. Decidedly inequilateral. Convexity fairly strong. Umbo moderately wide, fairly high. Lunule, as shown by internal molds, narrowly cordate, deeply depressed. Sculpture of wide flat concentric bands, separated by narrow interbands or striae. Interior unknown.

Length 85 mm, height 73 mm, convexity (both valves) 35 mm (figured right valve of articulated internal mold from upper member of Alhajuela formation, largest specimen).

The upper member of the Alhajuela formation yielded four internal molds that show some impressed sculpture, and the upper part of the Gatun formation, a minute valve (length 4.5 mm), all identified as *Dosina* aff. *D. ponderosa titan*, a subspecies of the living eastern Pacific *D. ponderosa* (Gray). They are characterized by wide concentric bands, even on the minute valve, and by the large size of mature specimens. At locality 89, this large species is associated with *D. delicatissima*.

Palmer (1927, p. 68, pl. 17, fig. 12) published an illustration of the lectotype of *D. grandis* (Nelson, 1870, p. 201), furnished by Prof. Dunbar, and Dunbar's comparison of that Peruvian species with the comparable Trinidad species *D. titan* (Maury 1925a, p. 139, pl. 24, figs. 1, 2, pl. 25, fig. 3). The same specimen of *D. grandis* was illustrated by Spieker (1922, p. 138, pl. 8, fig. 4) without any indication that it is from the Nelson collection. Spieker assigned his own specimens to the so-called variegated beds, which lie between the lower and upper parts of the Zorritos formation, although a note in the tray specifies that they were found in "wash" near the foot of a bluff containing "variegated and upper Zorritos." The preservation suggests the upper part of the Zorritos, of middle Miocene age. The largest specimen has a length of 81.5 mm. As shown by Olsson (1932, p. 29–33), the Nelson collection is from the late Miocene Tumbes formation. Palmer tentatively synonymized *D. titan* with *D. grandis*. Olsson (1961, p. 260) went farther and synonymized both taxa with the living eastern Pacific *D. ponderosa* (Gray).

The fossils from the upper member of the Alhajuela are most similar in sculptural plan to *D. titan*, which occurs in the late Miocene Savaneta glauconitic sandstone member and Melajo clay member of the Springvale formation. The fossils from the Alhajuela, however, are more inequilateral and do not reach the size of *D. titan*. Maury recorded a maximum length of 105 mm for that species; 100 mm is common. *D. grandis* is of comparable size (length 95 mm), but its sculpture is more irregular. Living *D. ponderosa* is the largest of all (length as great as 130 mm in USNM collections). No mature specimens in those collections have the wide concentric bands over the entire shell that are characteristic of *D. titan*. It may be best to consider *D. grandis* and *D. titan* as subspecies of *D. ponderosa*. In any event, no species comparable with *D. ponderosa* is known in western Atlantic waters later than late Miocene.

Inasmuch as the Alhajuela is considered to be late early Miocene in age, the large *Dosinia* in that formation is the earliest known ally of *D. ponderosa*.

An incomplete valve from the early Miocene Emperador limestone member of the La Boca formation at locality 129a, near Gaillard Cut, listed as *Dosinia*? sp., lacks dorsal, anterior, and posterior parts. The sculpture suggests a wide-banded *Dosinia*, but unless it is somewhat corroded, it seems to represent low lamellae.

Occurrence: Upper member of Alhajuela sandstone (early Miocene), localities 85, 89, 90a, 91. Upper part of Gatun formation (middle Miocene), eastern area, locality 177b.

Subfamiy CYCLININAE

Genus Cyclinella Dall

Dall, Nautilus, v. 16, no. 4, p. 44, August 4, 1902.

Type (logotype Dall U.S. Natl. Mus. Proc. v. 26, p. 357, December 29, 1902): *Dosinia tenuis* Récluz [*Dosinia* (*Artemis*) *tenuis* Récluz], living, North Carolina to Paraná, Brasil.

Small, presumably immature, specimens from the Caimito and Culebra formations, the Emperador limestone member of the La Boca formation, and the upper member of the Alhajuela formation are listed as *Cyclinella*? sp.

Cyclinella cyclica (Guppy)

Plate 120, figures 18, 19; plate 123, figures 3, 5

Dosinia cyclica Guppy, Geol. Soc. London Quart. Jour., v. 22, p. 582, pl. 26, figs. 15a, 15b, 1866 (Miocene, Trinidad).

Cyclina cyclica (Guppy)?, Gabb, Am. Philos. Soc. Trans., new ser., v. 15, p. 250, 1873 (Miocene, Dominican Republic).

Cyclina cyclica (Guppy), Gabb, Acad. Nat. Sci. Philadelphia Jour., 2d ser., v. 8, p. 344, 1881 (Miocene, Canal Zone).

Cyclinella cyclica (Guppy), Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 6, p. 1285, 1903 (Miocene, Trinidad). Maury, Bull. Am. Paleontology, v. 10, no. 42, p. 151, pl. 26, fig. 4, 1925 (Miocene, Trinidad). Palmer, Paleontographica Americana, v. 1, no. 5, p. 198, pl. 24, figs. 2 (Guppy's illustration), 7, 12 (Guppy's illustration), 1927 (Miocene, Trinidad).

Cyclinella cyclica domingensis Pilsbry and Johnson, Acad. Nat. Sci. Philadelphia Proc., v. 69, p. 200, 1917 (Miocene, Dominican Republic). Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 73, p. 424, pl. 47, fig. 8, 1922 (Miocene, Dominican Republic). Palmer, Palaeontographica Americana, v. 1, no. 5, p. 199, pl. 25, fig. 6 (Pilsbry's illustration), 1927 (Miocene, Dominican Republic). Anderson, California Acad. Sci. Proc., 4th ser., v. 18, no. 4, p. 167, 1929 (Miocene, Colombia).

Cyclinella gatunensis Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 6, p. 1285, pl. 52, fig. 18, 1903 (Miocene, Canal Zone). Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 63, p. 371, 1911 (Miocene, Canal Zone), Palmer, Palaeontographica Americana, v. 1, no. 5, p. 197, pl. 25, figs. 7, 15 (Dall's illustration), 16 (Miocene, Canal Zone, Darién). Anderson, California Acad. Sci. Proc., 4th ser., v. 18, no. 4, p. 167, 1929 (Miocene, Colombia).

Cyclinella venezuelana H. K. Hodson, *in* Hodson, Hodson, and Harris, Bull. Am. Paleontology, v. 13, no. 49, p. 59, pl. 34, figs. 3, 4, 1931 (Miocene Venezuela). Jung, Bull. Am. Paleontology, v. 49, no. 223, p. 455, pl. 57, fig. 9, 1965 (Miocene, Venezuela). Díaz de Gamero, Univ. Central Venezuela, Escuela Geol., Minas, Metalurgia Geos, no. 17, p. 36, pl. 3, fig. 2, 1968 (Miocene, Venezuela).

Moderately large, thin-shelled, suborbicular, height slightly less than length. Decidedly inequilateral to almost equilateral. Strongly convex. Posterior dorsal margin generally broadly rounding into lateral margin; exceptionally abruptly rounding. Umbo low, moderately wide. Lunule barely perceptible by faint circumscribed groove. Sculpture of fine, closely spaced, irregularly emphasized growth lines. Interior inaccessible on specimens from Gatun formation. Left hinge of a remaining syntype of *Cyclinella cyclica*: slender anterior, wedge-shaped middle, and fairly wide, thin-crested posterior cardinal teeth.

Length 39.2 mm, height 37 mm, convexity (both valves) 20.7 mm (lectotype of *C. cyclica*). Length 44.8 mm, height 43.4 mm, convexity (both valves, decreased by crushing) 15.2 mm (lectotype of *C. gatunensis*). Length 51 mm, height 49 mm, convexity (both valves) 25 mm (largest specimen from Gatun formation).

Type of *C. cyclica*: Lectotype, herewith designated, articulated specimen illustrated by Guppy, USNM 115541.

Type of *C. gatunensis*: Lectotype, herewith designated, somewhat crushed articulated specimen illustrated by Dall, USNM 135257.

Type locality of *C. cyclica*: Manzanilla, Trinidad, San Jose calcareous silt member of Manzanilla formation.

Type locality of *C. gatunensis*: 158 (USGS 2682, French Canal, about half a mile (800 m) south (southeast) of Gatun, Canal Zone), middle part of Gatun formation.

Cyclinella cyclica is widespread in the lower and middle parts of the Gatun formation: a total of 85 specimens, almost 60 percent of which are articulated; in fact, at 12 localities only articulated specimens were found. Minute shells are represented by a left valve that has an estimated length of 5 mm. A considerable range of variation is apparent in the degree of inequilaterality and in the rounding of the posterior dorsal margin into the lateral margin. The sculpture, however, is uniform on uncorroded valves.

The type material of *C. cyclica* consists of three syntypes. The lectotype is an articulated specimen of moderate size and moderate inequilaterality. One of the remaining syntypes is a fairly large left valve (length 45.5 mm) that lacks the dorsal part; the other is an incomplete left valve of moderate size showing the hinge. The lectotype of *C. gatunensis* is a somewhat crushed articulated specimen of moderate size; the remaining syntype is an incomplete small left valve. No essential features are apparent to distinguish *C. venezuelana*.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, localities 136, 136a, 137a, 138a, 138c, 138e. Middle part, eastern area, localities 139, 139c, 139e, 139g, 139h, 140, 141, 143, 144a, 145, 146, 147, 147a, 147c, 147h, 150, 150a, 153, 155, 158, 159d; western area, localities 160, 161, 162a. Miocene, presumably middle, Dominican Republic (Gabb's record). Deposits of middle Miocene age, Darién, Panáma (Palmer's record). Tubará formation, (middle Miocene), Atlántico Dept., Colombia, Cantaure formation (middle Miocene), Falcón, Venezuela. San Jose calcareous silt member of Manzanilla formation (middle Miocene), Trinidad. Urumaco (middle or late Miocene) and El Veral (late Miocene) formations, Falcón, Venezuela.

Subfamily CLEMENTIINAE

Genus Clementia Gray

Subgenus Clementia s.s.

Gray, Synopsis of the contents of the British Museum, 44th ed., p. 75, 1842 (genus without named species).

Type (monotype), Gray, Zool. Soc. London Proc., p. 184, 1847: *Venus papyracea* Gray, living, western Pacific Ocean.

The earliest species of *Clementia* s.s. appear in the Eocene of Perú, Colombia, Venezuela and Curaçao, and the last American species, in deposits of late Miocene age in the Miocene Caribbean province. In the Miocene of southeastern United States, *Clementia* s.s. is replaced by the subgenus *Egesta*, which ranged from Florida to New Jersey (Woodring, 1926, p. 36–39). *Egesta*, like *Clementia* s.s., is a paciphile subgenus. *Clementia solida* Dall (Woodring, 1926, p. 37, pl. 16, figs. 7, 8; Olsson, 1961, p. 265, pl. 50, figs. 5, 5a) is the sole surviving eastern Pacific species of *Egesta*.

Clementia (Clementia) dariena rabelli Maury

Plate 93, figures 1, 8

Clementia rabelli Maury, New York Acad. Sci., Scientific Survey of Porto Rico and the Virgin Islands, v. 3, pt. 1, p. 37, pl. 6, figs. 2, 3, 1920 (Oligocene, Puerto Rico). Maury, Bull. Am. Paleontology, v. 10, no. 42, p. 142 (in discussion), pl. 26, fig. 2 (Maury's 1920, fig. 2), 1925 (Oligocene, Puerto Rico).

Clementia (Clementia) dariena rabelli Maury, Woodring, U.S. Geol. Survey Prof. Paper 147–C, p. 34, pl. 14, fig. 5 (Maury's type), 1926 (Oligocene, Puerto Rico).

Clementia dariena (Conrad), Hubbard, New York Acad. Sci., Scientific Survey of Porto Rico and Virgin Islands, v. 3, pt. 2, p. 118, pl. 19, figs. 10, 11, 1920 (Oligocene, Puerto Rico). Maury, Bull. Am. Paleontology, v. 10, no. 42, p. 141, pl. 26, figs. 1, 3, 6, 7, 1925 (Miocene, Trinidad). Harris, *in* Waring, Johns Hopkins Univ. Studies in Geology, no. 7, p. 110, pl. 20, fig. 8, 1926 (Miocene, Trinidad). Palmer, Palaeontographica Americana, v. 1, no. 5, p. 202, pl. 26, figs. 14, 16 (Maury's illustrations of *C. rabelli*), 1927 (part, Oligocene, Puerto Rico; Miocene, Trinidad, Brasil).

Clementia brasiliana Maury, Brasil Serviço Geol. e Mineral. Mon. 4, p. 423, pl. 24, fig. 3, 1925 (Miocene, Brasil).

Clementia (Clementia) dariena dariena (Conrad), Woodring, U.S. Geol. Survey Prof. Paper 147–C, p. 34, pl. 14, fig. 11 (Maurys' type of *C. brasiliana*), 1926 (part, Oligocene, Puerto Rico, Veraguas Province, Panamá; Miocene, Costa Rica (identification doubtful), Trinidad. Brasil: Chiriquí Province, Panamá).

Clementia (Clementia) dariena (Conrad), Ferreira and Rodrigues da Cunha, Mus. Paraense Emilio Goeldi Bol., Geol., no. 8, p. 39, pl. 4, fig. 1, 1959 (Miocene, Brasil).

Occurrence of Clementia (Clementia) dariena rabelli

Age		Formation	USGS or other locality [1]	Number of specimens	Length, in mm. of largest specimen
Miocene	Middle	San Jose member of Manzanilla formation.	18257, 20425, 20426, 21765, Trinidad.	35	34 –36.5
	Early	Culebra.	25186(107a), 16951(108a), 16880(110), 16887(111a), 16888(111b), 16910(112).	14	36.5–estimated 48
		Unnamed.	6262, 6534, San Felix area, Chiriquí Province, Panamá. 10690, 10691, 10715, David area, Chiriquí Province, Panamá.	6	25 –estimated 45
		?	7274, Santa Maria de Dota. Puntarenas Province, Costa Rica.	[2] 1	33
		Pirabas.	Various localities in Pará, Brasil.	[3] about 10	17 –30
Oligocene	Late	Hershey's (1901) Santiago formation.	8465, USNM 647711, Santiago area, Veraguas Province, Panamá.	2	34.5–45
		Lower part of Lares limestone.	17219, 17221, San Sebastián area, Puerto Rico.	2	31 –estimated 43
			19780, Río Collazo area. Puerto Rico.	4	41.5
			San Sebastián area, Puerto Rico.	[4] 1 [4] 8 [5] 2	48 35 –41 43

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[1] Numbers in parentheses are report numbers of present account.

[2] Identification and age doubtful.

[3] Maury (1925b, p. 423), and Ferreira and Cunha, (1959, p. 42).

[4] Hubbard (1920, p. 119).

[5] Maury's type and paratype.

Similar to nominate subspecies (described under next heading), but smaller (length 35 to estimated 48 mm), and undulations generally extending to ventral margin, as on immature specimens of nominate subspecies. Interior inaccessible.

Length 39.7 mm, height 40.6 mm, convexity (both valves) 24.6 mm (larger illustrated specimen from Culebra formation). Length (almost complete) 46.6 mm (estimated restored length 48 mm), height 47 mm, convexity about 12 mm (largest specimen from Culebra formation).

Type: Am. Mus. Nat. History, Div. Geol. Invertebrate Paleontology, 22509.

Type locality: Río Collazo, San Sebastián area, Puerto Rico, San Sebastián formation.

The occurrence of *Clementia dariena rabelli* in USNM collections, supplemented by a few additional records, is shown in the table on p. 698.

It may be far-fetched to recognize *Clementia dariena rabelli* chiefly on the basis of size, as has been claimed (Jung, 1965, p. 459). Specimens from deposits of late Oligocene to late Miocene age present a continuum. The largest from the San Sebastián and Culebra formations (late Oligocene and early Miocene, respectively), assigned to *C. dariena rabelli*, and from the La Boca formation (early Miocene), assigned to *C. dariena dariena*, are on the borderline. Nevertheless, only one known exception to the generalization that increase in size is correlated with decreased age is apparent. That exception is the San Jose calcareous silt member of the Manzanilla formation of Trinidad, of late middle Miocene age. Only small specimens, recorded by Maury and Harris, have been recorded from that unit. The lower part of the San Jose on Caparo River (USGS 20456) yielded 29 specimens of *Clementia*, the largest of which has a length of 34 mm.

Occurrence: Culebra formation (early Miocene, localities 107a, 108a, 110, 111a, 111b, 112. San Sebastián formation and Lares limestone (late Oligocene) Puerto Rico. Hershey's (1901) Santiago formation (late Oligocene), Santiago area, Veraguas Province, Panamá. Pirabas formation (early Miocene), Brasil. Deposits of early Miocene age, Chiriquí Province, Panamá. San Jose calcareous silt member of Manzanilla formation (middle Miocene), Trinidad.

Clementia (Clementia) dariena dariena (Conrad)

Plate 99, figure 12; plate 118, figures 10, 11, 13, 15

Meretrix dariena Conrad, Appendix to the preliminary geological report of William P. Blake: U.S. 33d Cong., 1st Sess., House Doc. 129, p. 18, 1855; reprint Dall, U.S. Geol. Survey Prof. Paper 59, p. 170, 1909 (Miocene, Canal Zone). Conrad, *in* Blake, U.S. Pacific R. R. Explor., v. 5, app., art. 2, p. 328, pl. 6, fig. 55, 1857 (Miocene, Canal Zone).

Clementia (Clementia) dariena dariena (Conrad), Woodring, U.S. Geol. Survey Prof. Paper 147–C, p. 34, pl. 14, figs. 6–10, 1926 (part, Miocene, Canal Zone, Colombia). See this publication for other pre-1926 citations.

Clementia (Clementia) dariena (Conrad), Anderson, California Acad. Sci. Proc., 4th ser., v. 18, no. 4, p. 167, 1929 (Miocene, Colombia). Olsson, Bull. Am. Paleontology, v. 19, no. 68, p. 102, 1932 (Miocene Perú). Marks, Bull. Am. Paleontology, v. 33, no. 139, p. 73, 1951 (Miocene, Ecuador). Barrios, Colombia Servicio Geol. Nac., Bol. Geol., v. 6, nos. 1–3 (Informe 1082), p. 258, pl. 7, fig. 7, 1960 (Miocene, Colombia). Olsson, Neogene mollusks from northwestern Ecuador, p. 60, pl. 8, fig. 1, Paleontological Research Inst., 1964 (Miocene, Ecuador). Jung, Bull. Am. Paleontology, v. 49, no. 223, p. 456, pl. 57, figs. 11, 12, pl. 58, figs. 1–3, 1965 (Miocene, Venezuela). Diaz de Gamaro, Univ. Central Venezuela, Escuela Geol., Minas, Metalurgía, Geos, no. 17, p. 36, pl. 3, fig. 3, 1968 (Miocene, Venezuela).

Clementia dariena dariena (Conrad), Weisbord, Bull. Am. Paleontology, v. 14, no. 54, p. 24, pl. 5, fig. 1, 1929 (Miocene, Colombia).

Clementia dariena (Conrad), Palmer, Palaeontographica Americana, v. 1, no. 5, p. 147, pl. 26, figs. 6 (Conrad's illustration), 13, 15, 17, 18, 19 (Toula's illustration), 20, 1927 (part, Miocene, Costa Rica, Canal Zone, Darién, Colombia, Venezuela, Perú, Bocas del Toro area, Panamá). Hodson, Hodson, and Harris, Bull. Am. Paleontology, v. 13, no. 49, p. 52, pl. 32, fig. 3, 1927 (Miocene, Venezuela). Li, Geol. Soc. China Bull., v. 9, no. 3, p. 259, pl. 4, fig. 24, 1930 (alleged to have been dredged in Panama Bay). Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 83, p. 430, 1931 (Li's specimen is labelled as from "the underlying surface clays of Gatun locks and Spillway sites"). Haas, Jour. Paleontology, v. 16, no. 3, p. 308 (list), 1942 (Miocene, Costa Rica). Zoppis Bracci and del Giudice, Nicaragua Servicio Geol. Nac. Bol. 2, p. 40 (list), 1958 (Miocene, Nicaragua). Woodring, Inst. Centroamericano Invest. Tec. Ind. (ICAITI), Pub. Geol., no. 4, p. 184 (list), 1973 (1974) (Miocene, Costa Rica).

Moderately large, thin shelled, generally ovate and decidedly inequilateral (exceptionally ranging to suborbicular), strongly convex. Posterior end more broadly rounded than anterior. Umbo moderately low, moderately wide. Lunule and escutcheon absent. Sculpture of concentric undulations generally on dorsal half to two-thirds of mature shells, replaced adventrally by narrow, closely spaced lamellae or growth lines; exceptionally undulations on mature shells extending almost, or even entirely, to ventral margin. Hinge of right valve: slender anterior, wider middle, posterior face of which is convex, and moderately slender posterior, ventral half bifid, cardinal teeth. Hinge of left valve: slender, wedge-shaped anterior, wider wedge-shaped middle, crest of which is narrow, and slender posterior cardinal teeth. Pallial sinus indistinct.

Length 51.7 mm, height 47 mm, convexity (both valves) 26.5 mm (figured specimen from La Boca formation). Length 60.5 mm, height 50 mm, convexity (both valves) 33 mm (largest figured specimen from lower part of Gatun formation). Length 70 mm, height 65.5 mm, convexity (both valves) 22.5 mm (largest essentially complete specimen from the Gatun.

Type: Lost.

Type locality: Cut on Panama Railroad at precanal Gatun, Canal Zone, middle part of Gatun formation. According to Blake's account of his trip across Panamá in 1853 (Blake, 1857, p. 1), "at Gatun, or Monkey Hill?, where we stopped for a few moments, I obtained several fossil shell from the embankment at the side of the road [railroad] * * * the genera *Gratelupia* [*Lirophora*], *Meretrix* [*Clementia*], and *Tellina*." The railroad cut surely was at Gatun; *Clementia* is unknown at Monkey Hill, Mount Hope of present terminology.

Two specimens from the La Boca formation, one of which is illustrated (pl. 99, fig. 12), are identified as *Clementia dariena dariena*. As a matter of fact, those two specimens, both from locality 101h, are intermediate in size between *C. dariena rabelli* and *C. dariena dariena*, as it occurs in the Gatun formation. The remaining four specimens from the La Boca, collected at four localities, are small, or very small. They are listed as *C. dariena* subsp.?.

In the Gatun, the nominate subspecies is represented by 140 specimens, 94 percent of which are articulated. The subspecies is abundant in the lower part only at locality 138c, but in the middle part it is widespread and locally common. On the whole, preservation is better in the lower part than in the middle. Some specimens, especially in the middle part, are distorted, a few are corroded, and still fewer are internal molds. Two minute valves (length 1.8 and 2.3 mm) are the only ones collected at locality 136a.

The designation of a neotype (Woodring, 1926, p. 35, pl. 14, fig. 10) is to be ignored. It was collected in a railroad cut postdating Blake's trip by a span of half a century. The plug at the south end of the Gatun Third Locks excavation (bed 1 of section on page 44 of chapter A) is a likely extension of the bed formerly exposed in a railroad cut at Gatun, although it is about 1.2 km northeast of the now-submerged original alinement of the Panama Railroad at Gatun. The 18 specimens, one of which is illustrated (pl. 119, fig. 10), collected from bed 1 (locality 153) may be regarded as probable topotypes. In any event, a neotype is not needed.

Throughout the Tertiary Caribbean province, *C. dariena dariena* has an age range of early to late Miocene. The genus is unknown in the western Atlantic later than late Miocene. An articulated internal mold (USNM 563419) is in Guppy's collection from the Savaneta glauconitic sandstone member of the Springvale formation of Trinidad. The typed label, certainly not Guppy's, reads *Clementia tamiosa* (corrected to *taeniosa*), holotype. It is not, however, the type of that species of Guppy, which is a species of *Harvella* (type, USNM 107106); it is a specimen of *C. dariena dariena*. Its length is 72.7 mm, slightly larger than the largest from the Gatun. It is the only known specimen from the Springvale, despite a record of the occurrence in an American Museum of Natural History collection (Vokes, 1938, p. 3), According to a communication from Dr. Roger L. Batten, no specimen from Trinidad is in that museum.

Occurrence: La Boca formation (early Miocene), Gaillard Cut area, locality 101h. Lower and middle parts of Gatun formation (middle Miocene). Lower part, localities 136a, 137a, 138a, 138c, 138e, 138h. Middle part, eastern area, localities 139b, 139c, 139e, 139f, 139g, 139h, 140, 143, 144, 145, 146, 147, 147a, 147d, 149, 150a, 153, 153a, 155, 155c, 158, 159d; western area, localities 160, 161. Gabb's early Miocene locality at Sapote (Zapote), Río Reventazón, Costa Rica. USGS 11618 and other localities in early Miocene deposits in Río Sinú area, Córdoba Dept. Colombia. Punta Carballo formation (early Miocene), Puntarenas Province, Costa Rica. Early Miocene deposits at Cabo Pesados, Ecuador. Lower part of Zorritos formation (early Miocene), Perú. Middle Miocene deposits, Limón Province, Costa Rica. Middle Miocene deposits, Darién, Panamá (Palmer's record). Tubará formation (middle Miocene), Atlántico Department, Colombia. Cantaure and other middle Miocene formations, Falcón, Venezuela. Middle Miocene part of Moruga formation, Trinidad (USGS 21076). El Fraile formation (middle Miocene), Nicaragua (Zoppis Bracci and del Giudice's record). Progreso formation (middle Miocene), Ecuador. Upper part of Zorritos formation and Montera formation (both middle Miocene), Perú. Limónes formation (late Miocene), Bocas del Toro area, Panamá (Olsson's record). El Veral formation (late Miocene), Falcón, Venezuela. Savaneta glauconitic sandstone member of Springvale formation (late Miocene), Trinidad.

Subfamily CHIONINAE

Genus Chione Megerle von Muhlfeld

Megerle von Mühlfeld, Gesellschaft Naturforschender Freunde, 5th year, p. 51, 1811.

Type (logotype, Gray, Zool. Soc. London Proc., p. 546, 1847): *Venus dysera* Linné of Megerle (=*Venus cancellata* Linné), living, North Carolina to São Paulo, Brasil.

Small valves from the Caimito formation and incomplete external molds from the Toro limestone member of the Chagres sandstone are listed as *Chion* sp.

Subgenus Chionopsis Olsson

Olsson, Bull. Am. Paleontology, v. 19, no. 61, p. 111, 1932.

Type (orthotype): *Chione amathusia* Philippi (*Venus amathusia* Philippi), living, Gulf of California to northern Perú.

Chione (Chionopsis) cf. C. (C.) posorjensis Olsson

Plate 91, figures 18, 19

Small, trigonal-ovate, decidedly inequilateral, strongly convex. Anterior dorsal margin slightly concave; posterior dorsal-lateral margin slightly convex to practically straight. Posterior end narrower than anterior. Umbo moderately high, of moderate width. Lunule cordate, circumscribed by deep groove. Sculpture not well preserved, consisting of low concentric lamellae, frilled by very narrow, closely spaced radial threads, subdued in interlamellae. Hinge defective and pallial sinus indistinct on only valve showing interior. Inner margin, including lunular margin, denticulate.

Length 24.4 mm, height 19 mm, convexity about 8 mm (larger figured valve). Length 28.5 mm, height 24 mm, convexity about 9 mm (largest specimen).

The upper part of the Bohio formation on Barro Colorado Island yielded 29 specimens of *Chione*. They are internal molds that retain at least some shell material, for the most part corroded. The length range is 2.7 to 28.5 mm.

This species has a higher umbo than *C. posorjensis* (Olsson, 1931, p. 62, pl. 8, figs. 4, 6; late Oligocene, Ecuador, Perú) and is more convex. It is much more elongate than *C. bainbridgensis* (Dall, 1916, p. 499, pl. 84, figs. 5, 6; late Oligocene, Georgia; Mansfield, 1937, p. 269, recorded as *C.* aff. *C. bainbridgensis;* late Oligocene, Florida) and *C. spenceri* (Cooke, 1919, p. 150, pl. 15, figs. 1a, 1b; late Oligocene, Antigua; Mansfield, 1937, p. 270, pl. 21, fig. 5, recorded as *C.* cf. *C. spenceri*; early Miocene, Florida; Mansfield, 1938, p. 105, figs. 8, 16, recorded as *C.* cf. *C. spenceri;* late Oligocene, Florida), which evidently is a synonym of *C. bainbridgensis*.

Occurrence: Upper part of Bohio formation (late Oligocene), localities 42d, 42f, 42g, 42i.

Chione (Chionopsis) propinqua Spieker

Plate 100, figure 1

Chione (*Chione*) *propinqua* Spieker, Johns Hopkins University Studies in Geology, no. 3, p. 152, pl. 9, fig. 12, 1922 (Miocene, Perú.)

Chione (*Chionopsis*) *propinqua* Spieker, Olsson, Bull. Am. Paleontology, v. 19, no. 68, p. 112, pl. 11, figs. 2, 3, 8, 1932 (Miocene, Perú). Marks, Bull. Am. Paleontology, v. 33, no. 139, p. 80, 1951 (Miocene, Ecuador).

Small to medium size, trigonal-ovate, decidedly inequilateral, moderately convex. Anterior dorsal margin concave; posterior dorsal-lateral margin slightly convex. Posterior end narrower than anterior. Umbo low, moderately wide. Lunule cordate, circumscribed by deep groove. Sculpture of relatively widely spaced concentric lamellae, frilled by narrow, relatively widely spaced radial threads. Hinge defective or inaccessible. Pallial sinus and inner margin inaccessible.

Length 26.6 mm, height 23.5 mm, convexity 9.6 mm (figured right valve). Length (incomplete) 28 mm (estimated restored length 32 mm), height 28 mm, convexity about 6.5 mm (largest valve, crushed).

Type (left valve): USNM 562418; paratype (left valve): USNM 562419.

Type and paratype locality: Quebrada Zapotal, Zorritos area, Perú, lower part of Zorritos formation.

The fauna of the La Boca formation includes 43 specimens of *Chione propinqua*. They are not well preserved, and many are incomplete.

The type material is poorly preserved, and the anterior part shown on the drawing is restored. The topotypes illustrated by Olsson show to much better advantage the features of the species.

Occurrence: La Boca formation (early Miocene), Gaillard Cut area, localities 99b, 100, 115, 115b, 116a, 119, 119a. Lower part of Zorritos formation (early Miocene, Perú). Subibaja formation (early Miocene), Ecuador. Progreso and Daule formations (middle Miocene), Ecuador.

Chione (Chionopsis) eurylopas Woodring, n. sp.

Plate 102, figure 6

Of medium size, elongate trigonal-ovate, decidedly inequilateral, strongly convex. Anterior dorsal margin slightly concave; posterior dorsal-lateral margin very slightly convex. Posterior end bluntly pointed. Umbo low, wide. Lunule not exposed. Sculpture of wide, widely spaced, concentric lamellae, frilled by widely spaced interlamellar radial threads. Interior inaccessible.

Length 36.6 mm, height 26.3 mm, convexity 14.4 mm (type).

Type (left valve): USNM 647727.

Type locality: 99b (USGS 6019b, west side of Las Cascadas Reach, unit 11 of MacDonald's section (MacDonald, 1919 p. 538), Canal Zone), La Boca formation.

The concentric lamellae of *Chione eurylopas* are exceptionally wide. At the type locality six specimens are associated with *C. propinqua*. The type is the only one that is practically complete. Two incomplete valves were collected at localities 100b and 116. In addition, two internal molds that retain traces of sculpture were found at locality 101h. Owing to the type of preservation, the illustration is unsatisfactory.

C. sechuntana (Hanna and Israelsky, 1925, p. 47, pl. 7, fig. 3) is the only species having comparably wide concentric lamellae that has come to my attention. It was based on a small incomplete subcircular valve (length 23.5 mm) from the Zorritos formation of Perú.

Occurrence: La Boca formation (early Miocene), Gaillard Cut area, localities 99b, 100b, 101h, 116.

Chione (Chionopsis) tegulum Brown and Pilsbry

Plate 120, figures 16, 17, 22

Chione tegulum Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 63, p. 368, pl. 28, fig. 8, 1911 (Miocene, Canal Zone). Palmer, Palaeontographica Americana, v. 1, no. 5, p. 146, pl. 39, fig. 20 (printed 19, Brown and Pilsbry's illustration), 1927 (Miocene, Canal Zone).

Chionopsis tegulum (Brown and Pilsbry), Olsson, Neogene mollusks from northwestern Ecuador, p. 63, pl. 8, figs. 8 (type), 8a, Paleontological Research Inst., 1964 (Miocene, Canal Zone, Costa Rica).

Chione (Chione) paraguanensis H. K. Hodson, *in* Hodson, Hodson, and Harris, Bull. Am. Paleontology, v. 13, no. 49, p. 62, pl. 35, figs. 2, 7, 1927 (Miocene, Venezuela).

Chione (Chionopsis) paraguanensis H. K. Hodson, Jung, Bull. Am. Paleontology, v. 49, no. 223, p. 465, pl. 59, figs. 6–9, 1965 (Miocene, Venezuela).

Large, trigonal-ovate, decidedly inequilateral, strongly convex. Anterior dorsal margin strongly concave; posterior dorsal-lateral margin slightly convex. Posterior end bluntly pointed; wide, shallow depression at and near ventral margin on posterior slope. Umbo high, wide. Lunule cordate, circumscribed by deep groove, sculptured with exaggerated growth lines. Escutcheon narrow, smooth, aside from few growth lines. Concentric lamellae relatively widely spaced, but crowded near ventral margin on some shells. Lamellae upturned, frilled by closely spaced, flat radial threads. Radial threads undivided to height of 9 to 22 mm (generally about 12). Thereafter threads divided into two parts, and faint secondary thread appearing in interradials. Edge of lamellae then having twice as many frills, and ventral face of the lamellae twice as many threads. Hinge of right valve: slender anterior, wider middle (dorsal part bifid), and wide posterior (dorsal part broadly bifid) cardinal teeth. Hinge of left valve not exposed. Inner margin, including lunular margin, denticulate. Pallial sinus short, apex angular.

For dimensions see following table.

Type (immature left valve): Acad. Nat. Sci. Philadelphia 1761.

Type locality: Presumably Gatun Locks Excavation, Canal Zone, middle part of Gatun formation.

Dimensions of specimens of Chione (Chionopsis) tegulum

Age		Specimen	Locality	Dimensions, in mm		
				Length	Height	Convexity
Gatun formation	Upper part, western area	Largest	182	62.3	49	22
		Illustrated	182a	59	46	20
	Middle and lower parts	Largest	144a	48.5	38.5	30
	Middle part	Type	presumably Gatun Locks	20	19.5	7.5
	Lower part	Illustrated	Stanford 2611	17.5	14.6	about 6
		Illustrated	138h	46	38	both valves 32.2

Chione tegulum is widespread in the lower and middle parts of the Gatun formation and occurs also in the upper part: 296 specimens, many of which are articulated. Minute specimens (length 1.1 mm to a few mm) are not unusual. The only specimens from the upper part in the eastern area are very small (length of largest 4.5 mm). As shown by the preceding table, the size in the upper part in the western area is considerably larger than in the lower and middle parts—a feature shown also by *Dosinia delicatissima*. On the whole, preservation in the lower part and in the upper part in the western area is better than in the middle part.

The type, which was reillustrated by Olsson, is an immature left valve that has not reached the stage when the radial threads are divided. It bears little resemblance to mature valves.

C. paraguanensis closely agrees with *C. tegulum*. *C. spiekeri* (Olsson, 1932, p. 112, pl. 3, fig. 7, pl. 12, figs. 4, 5; Miocene, Perú is closely related but is poorly preserved. *C. dauleana* (Marks, 1951, p. 81, pl. 5, figs. 5, 8; Miocene, Ecuador) is perhaps to be treated as a large subspecies of *C. tegulum*.

Four internal molds from the lower member of the Alhajuela formation are doubtfully identified as *C. tegulum*.

Occurrence: Lower member of Alhajuela formation (early Miocene), identification doubtful, localities 79, 82. Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, localities 135, 136, 136a, 137, 137a, 138, 138a, 138c, 138d, 138f, 138g, 138h. Middle part, eastern area, localities 139, 139c, 139e, 139g, 140, 141, 143, 144, 144a, 145, 146, 147, 147a, 147h, 147j, 153, 155, 155b, 158, 159d; western area, localities 160, 161, 161c, 162, 170a. Upper part, eastern area, locality 173; western area, localities 182, 182a. Deposits of middle Miocene age, Limón Province, Costa Rica (Olsson's record). Cantaure formation (middle Miocene), Falcón, Venezuela.

Genus Lirophora Conrad

Conrad, Acad. Nat. Sci. Philadelphia Proc., 1862 [2d ser., v. 6], p. 575, 586.

Type (logotype, Dall, U.S. Natl. Mus. Proc., v. 26, p. 358, 1902): *Venus athleta* Conrad [*Circumphalus* (*Venus*) *athleta*, as published by Conrad in 1862)] =*Lirophora latilirata* (Conrad), Miocene to living, southeastern United States.

Lirophora (Lirophora) cf. L. (L.) quirosensis (H. K. Hodson)

Plate 98, figure 3

Small to medium size, ovate, moderately inequilateral; exceptionally decidedly inequilateral. Moderately convex. Anterior dorsal margin slightly concave; posterior dorsal-lateral margin practically straight. Posterior end more narrowly rounded than anterior. Umbo low, narrow. As shown by impression, lunule short, cordate. Sculpture of widely spaced concentric lamellae, base narrow at early stage, somewhat wider at later stage. Interior inaccessible.

Length 30 mm, height 25.4 mm, convexity about 8 mm (figured left valve).

A species of *Lirophora* is represented in the Culebra formation by one valve and in the La Boca formation by 34, 26 of which, ranging in length from 7.5 to 29.2 mm, were collected at locality 99c. All are internal molds that retain the base of the concentric lamellae. A right valve from the La Boca at locality 114, the only specimen from that locality, is exceptional in its strong inequilaterality.

The illustrated left valve, the largest complete specimen, is comparable in size and outline to *L. quirosensis* (H. K. Hodson, *in* Hodson, Hodson, and Harris, 1927, p. 62, pl. 35, fig. 9), the type of which is from the early Miocene La Rosa formation cropping out at El Mene de Saladillo, in the state of Zulia, Venezuela. *L. quirosensis* bears very fine concentric threads in the interlamellae. Such sculpture would not show on the Canal Zone fossils, even if it were present originally. The early concentric lamellae of the Canal Zone fossils, however, are more widely spaced than those of *L. quirosensis*.

Occurrence: Culebra formation (early Miocene), locality 106. La Boca formation (early Miocene), Gaillard Cut area, localities 99a, 99b, 99c, 99d, 99h, 114, 119.

Lirophora (Lirophora) falconensis (H. K. Hodson)

Plate 119, figures 1, 7

Chione (*Lirophora*) *falconensis* H. K. Hodson, *in* Hodson, Hodson, and Harris, Bull. Am. Paleontology, v. 13, no. 49, p. 63, pl. 35, fig. 10, 1927 (Miocene, Venezuela).

Chione (*Lirophora*) *tembla* Olsson, Neogene mollusks from northwestern Ecuador, p. 62, pl. 8, fig. 7, Paleontological Research Inst., 1964 (Miocene, Ecuador).

?*Chione* (*Lirophora*) aff. *C.* (*L.*) *latilirata* (Conrad), Marks, Bull. Am. Paleontology, v. 33, no. 139, p. 82, 1951 (Miocene, Ecuador).

?*Chione* (*Lirophora*) sp. b, Marks, Bull. Am. Paleontology, v. 33, no. 139, p. 83, 1951 (Miocene, Ecuador).

Of medium size, ovate, moderately inequilateral, moderately convex. Anterior dorsal margin concave; posterior dorsal-lateral margin practically straight. Posterior end slightly more narrowly rounded than anterior. Umbo moderately wide and high. Lunule large for size of shell, cordate, circumscribed by deep groove. Lunule narrow. Both lunule and escutcheon sculptured with growth lines. Sculpture generally of moderately wide, generally moderately spaced, upturned concentric lamellae; exceptionally narrow and closely spaced. Fine radial pits at ventral base of lamellae, especially on early lamellae. Pits formed by short, very narrow, very closely spaced radial threads. Lamellae foliaceous, but broken down to base, on posterior slope; somewhat foliaceous at extreme anterior end of shell. Fine concentric interlamellar threads near ventral margin on some shells. Hinge of right valve: short, slender anterior, wedge-shaped middle, and long, slender posterior cardinal teeth. Hinge of left valve: cardinal teeth like those of right valve. Inner margin, including lunular margin, finely denticulate. Pallial sinus short, apex angular.

Length 27.7 mm, height 22 mm, convexity 9.3 mm (figured right valve from lower part of Gatun formation). Length 28.5 mm, height 23.9 mm, convexity 10.2 mm (largest specimen from the Gatun). Length 22 mm, height 18 mm, convexity (both valves) 13 mm (type of *Lirophora falconensis*).

Type (left valve): Paleontological Research Inst. 22851.

Type locality: West of Urumaco, District of Democracia, Falcón, Venezuela, Urumaco formation (middle or late Miocene).

Type of *Chione* (*Lirophora*) *tembla* (left valve): USNM 643833.

Type locality of *Chione* (*Lirophora*) *tembla*: Telembi, Río Cayapas, Ecuador, Angostura formation.

Though the largest Canal Zone fossil identified as *Lirophora falconensis* is considerably larger than the type of that species and the type of *L. tembla*, the outline and average sculptural pattern agree with both. A right valve collected at locality 139b, the only such specimen, has exceptionally narrow and closely spaced concentric lamellae (pl. 119, fig. 7).

As pointed out by H. K. Hodson, the radial pits at the ventral base of concentric lamellae are an expression of the hidden radial sculpture.

L. falconensis occurs in the Gatun formation, except in the upper part in the eastern area: 130 specimens, only three of which are articulated. It is especially abundant and well preserved in the lower part of the formation. Minute valves, having lengths of 1 to 2.5 mm are common.

Two internal molds from the lower member of the Alhajuela formation are doubtfully identified as *L. falconensis*.

Occurrence: Lower member of Alhajuela formation (early Miocene), locality 82 (identification doubtful). Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, localities 137, 137a, 138, 138c, 138d, 138h. Middle part, eastern area, localities 139b, 139c, 139e, 139h, 144, 159d; western area, localities 161, 162, 162a, 169. Upper part, western area, locality 182. Angostura formation (middle Miocene), Ecuador. Urumaco formation (middle or late Miocene), Falcón, Venezuela.

Subgenus Panchione Olsson

Olsson, Neogene mollusks from northwestern Ecuador, p. 62, Paleontological Research Inst., 1964.

Type (orthotype): *Chione mactropsis* (Conrad) (*Grateloupia*? *mactropsis* Conrad), Miocene, Canal Zone.

Panchione is a paciphile subgenus. Its age range in western Atlantic areas is early to late Miocene.

Lirophora (Panchione) species a

?*Chione* (*Lirophora*) *ulocyma* (Dall), Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 64, p. 503 (list) 1913 (early Miocene, Canal Zone).

Five valves from the La Boca formation and two from the upper member of the Alhajuela formation are assigned to *Panchione*. They are sculptured with narrow, closely spaced concentric lamellae, which bear very narrow, very closely spaced radial threads. The interior is inaccessible.

Length (incomplete) 23 mm (estimated restored length 25 mm), height 21 mm, convexity 12 mm (largest valve from the La Boca). Length 29.5 mm, height 25 mm, convexity about 8 mm (larger valve from upper member of the Alhajuela).

An external mold and an internal mold from the Culebra formation, and an internal mold from the La Boca are listed as *Lirophora* (*Panchione*?) sp. b. These fossils have wide concentric lamellae. None shows radial sculpture.

Occurrence: La Boca formation (early Miocene), locality 116a. Upper member of Alhajuela formation (early Miocene), locality 92.

Lirophora (Panchione) mactropsis (Conrad)

Plate 119, figures 12, 13, 15–19

Grateloupia? *mactropsis* Conrad, Appendix to the preliminary geological report of William P. Blake: U.S. 33d Cong., 1st Sess., House Doc., 129, p. 18, 1855; reprint Dall, U.S. Geol. Survey Prof. Paper 59. p. 170, 1909 (Miocene, Canal Zone). Conrad, *in* Blake, U.S. Pacific R. R. Explor., v. 5, app., art, 2, p. 328, pl. 6, p. 54, 1857 (Miocene Canal Zone).

Chione (*Lirophora*) *mactropsis* (Conrad), Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 6, p. 1294, 1903 (Miocene, Canal Zone). Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 63, p. 369, 1911 (Miocene, Canal Zone, Dall's record). Palmer, Palaeontographica Americana, v. 1, no. 5, p. 175, pl. 43, figs. 3, 12 (Conrad's illustration), 17, 1927 (Miocene, Canal Zone, Costa Rica). Anderson, California Acad. Sci. Proc., 4th ser., v. 18, no. 4, p. 171, 1929 (Miocene, Colombia). Haas, Jour. Paleontology, v. 16, p. 309 (list), 1942 (Miocene, Costa Rica).

Chione mactropsis (Conrad), Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 245 (assigned to section *Lirophora*), pl. 30, figs. 7, 8, 1922 (Miocene, Canal Zone, Costa Rica).

Chione (*Panchione*) *mactropsis* (Conrad), Olsson, Neogene mollusks from northwestern Ecuador, p. 62, pl. 8, figs. 6, 6a, Paleontological Research Inst., 1964 (Miocene, Ecuador).

Chione sulcata Gabb, Acad. Nat. Sci. Philadelphia, 1860, p. 567, 1861 (Miocene, Panamá).

Venus (*Chione*) *Ebergenyii* Böse, Inst. Geol. México Bol. 22, p. 28, pl. 2, figs. 4–17, 1906 (Miocene, México); not p. 82, pl. 11, figs. 8, 9 (Pliocene, México).

Chione (*Lirophora*) *ebergenyii* (Böse), Alancaster-Ibarra, *in* Masson and Alancaster-Ibarra, Asoc. Mexicana Geol. Petroleros Bol., v. 3, nos. 5–6, p. 207, figs. 12–14, 1951 (Miocene, México).

Chione ebergenyii (Böse), Alancaster Y, *in* Ríos Macbeth, Asoc. Mexicana Geol. Petroleros Bol., v. 4, nos. 9–10, p. 346 (list), 347 (list), pl. 19, figs. 10, 11, 1952 (Miocene, México).

Not *Venus ebergenyii* (Böse), Li, Geol. Soc. China Bull., v. 9, p. 259, pl. 4, fig. 25, 1930 (alleged to be Miocene, Panama Bay) (=*Chione* (*Lirophora*) *mariae* (d'Orbigny), Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 83, p. 430, 1931, living, Panama Bay).

?*Venus ulocyma* Dall?, Engerrand and Urbana, Soc. Geol. Mexicana Bol., v. 6, pt. 2, p. 132, 1910 (Miocene, México).

Chione (*Venus, Lirophora, Anaitis*) *ulocyma* Dall, Toula, K. k. Geol. Reichsanstalt Jahrb., v. 58, p. 724, pl. 25, figs. 20–22, 1909 (Miocene, Canal Zone).

Chione (*Lirophora*) *ulocyma* (Dall), Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 63, p. 369, 1911 (Miocene, Canal Zone).

Venus (*Chione*) *ulocyma* Dall, Barrios, Colombia Servicio Geol. Nac. Bol. Geol., v. 6, nos. 1–3 (Informe 1082), p. 257, pl. 7, fig. 6, 1960 (Miocene, Colombia).

Chione (*Lirophora*) *ulocyma holocyma* Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 63, p. 369 (in discussion), 1911 (Miocene, Canal Zone).

Chione holocyma Brown and Pilsbry, Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 247 (assigned to section *Lirophora*), pl. 30, fig. 9, 1922 (Miocene, Canal Zone).

Chione (*Lirophora*) *holocyma* Brown and Pilsbry, Palmer, Palaeontographica Americana, v. 1, no. 5, p. 174, pl. 42, fig. 34, 1922 (Miocene, Canal Zone).

Chione (*Lirophora*) *buenavistana* (*buenavista* on p. 65, corrected to *buenavistana* in errata) H. K. Hodson, *in* Hodson, Hodson, and Harris, Bull. Am. Paleontology, v. 13, no. 49, p. 65, pl. 36, fig. 11, 1927 (Miocene, Venezuela).

Lepas injudicata Pilsbry, U.S. Natl. Mus. Bull. 103, p. 188, pl. 67, fig. 5, 1918 (Miocene, Canal Zone); reissued in consolidated volume, 1919.

Moderately large, ovate, moderately inequilateral, strongly convex. Anterior dorsal margin concave; posterior dorsal-lateral margin slightly convex to practically straight. Posterior end slightly more narrowly rounded than anterior. Umbo of moderate height, wide. Lunule large, cordate, circumscribed by deep groove. Escutcheon narrow. Both lunule and escutcheon, as usual, sculptured with growth lines. Sculpture highly variable. Concentric sculpture consisting of wide, thickened, upturned lamellae, like those of *Lirophora* s.s., or converted into much narrower bands of variable width, separated by deep grooves of variable width (such specimens generally recorded as *Lirophora ulocyma*). Radial sculpture exceptionally limited to pits at ventral base of lamellae (as on *L. falconensis*), but almost invariably present on concentric lamellae or bands, as very narrow flat riblets, ranging from faint to strong. Strong sculpture resulting from depth of striae between very narrow flat riblets (specimens showing strong radial sculpture recorded as *L. ulocyma holocyma*). Widely spaced foliaceous lamellae on posterior slope, and lamellae or bands somewhat foliaceous at extreme anterior end of shell, both sets as on *Lirophora* s.s., and both generally broken back. Hinge, pallial sinus, and interior margin like those features of *L. falconensis*.

Length 45 mm, height 34.5 mm, convexity 13 mm (largest specimen from Gatun formation). For dimensions of types and specimens illustrated in present account see the table on p. 706.

Type of *Lirophora mactropsis* (internal mold of articulated specimen): USNM 1843.

Type locality of *L. mactropsis*: railroad cut at precanal Gatun, middle part of Gatun formation. See discussion of type locality of *Clementia dariena dariena*, p. 700.

Type material of *L. ulocyma holocyma*: Lectotype (right valve), herewith designated: Acad. Nat. Sci. Philadelphia 1763.

Type locality of *L. ulocyma holocyma*: presumably Gatun Locks excavation, middle part of Gatun formation.

Lirophora mactropsis was one of the first three species of mollusks to be described from the Gatun formation. Unlike the other two, the type is still extant. Though it is an internal mold of an articulated specimen that retains some inner shell material showing no sculpture (pl. 119, fig. 19), it shows inner fine denticulation on much of the ventral and anterior margins of both valves. It is duplicated in outline by internal molds, associated with preserved shells, collected at localities 147d, 147h, and 160, in the middle part of the Gatun.

This species is the most abundant venerid in the Gatun. It occurs throughout the formation: an estimated 1,200 specimens. Articulated specimens are common. Minute shells, ranging in length from 1.2 to a few mm, are widespread and locally abundant, especially at localities 147b, 147g, and 177b. One of the minute specimens (locality 147h, length 4.5 mm) is articulated, and despite its size, one valve is bored.

In southeastern Costa Rica, the species reaches a slightly larger size (maximum recorded length 51.5 mm) than in Panamá. In México, however, it is slightly smaller than in Panamá (maximum recorded length 38 mm).

L. mactropsis is polymorphic so far as sculpture is concerned. The sculpture on the ventral half of the shell may be divided into five main types, listed in the following table:

Sculpture of Lirophora mactropsis *and dimensions of types and other specimens illustrated in present account*

Type of sculpture	Sculpture		Illustration (pl. 119)	Specimen	Locality	Dimensions (in mm [1])
	Concentric	Radial				
-	None	None	fig. 19	Type	Pre-canal Gatun.	42.3, 30. both valves 20.3
1	Thick, wide lamellae.	Limited to pits at ventral base of lamellae.	fig. 15	Right valve	138e	34.8, 28.3, 11.3
2	Flattened, wide thick lamellae.	Faint on lamellae.	fig. 12	Left valve	139e	39.6, 30.7, 11.2
3	Moderately narrow lamellae.	Narrow, flat riblets, separated by striae.	fig. 17	Left valve	183	45, 34.5, 13
4	Moderately narrow bands.	Narrow, flat riblets, separated by striae.	fig. 18	Left valve	155a	43, 34, 14
5	Narrow bands	Very narrow, flat riblets, separated by deep striae.	fig. 16	Lectotype of *ulocyma holocyma*.	Gatun Locks excavation.	30, 24, 8.5
			fig. 13	Left valve	139h	35, 27.5, both valves 19.6

[1] Order of dimensions: length, height, convexity.

Type 1 is exceptional. Two of 18 valves collected at locality 138e, in the lower part of the Gatun, have faint radial sculpture on the lamellae. The remainder, including that illustrated, have none. They resemble species of *Lirophora* s.s. that have radial pits at the ventral base of the lamellae, except that the lamellae are thick and wide.

Type 2 is especially characteristic of the lower part of the Gatun but reappears also in the middle part and even in the upper part.

Type 3 is the prevailing type in the middle part. If the 10 specimens collected at locality 153 are probable topotypes, as was deduced for *Clementia dariena dariena*, it probably was the type of sculpture for the type specimen.

Type 4 is the *L. ulocyma* type. Intermediates between type 3 and type 4 are apparent.

Type 5 is the *L. ulocyma holocyma* type. The right valve illustrated on plate 119, fig. 16, selected from six syntypes, none of which was heretofore illustrated, is the lectotype of that form. Intermediates between types 4 and 5 are common. The collection from locality 138c includes three specimens showing type 5 sculpture. No intermediates, however, are present between those three and the other 23 mature specimens, all of type 2.

What controls this remarkable range of sculpture? It may possibly be subtle differences in microenvironment.

The type, and only specimen, of *Lepas injudicata* was collected at locality 147a. The collection from that locality includes three more or less corroded specimens of *Lirophora mactropsis*. Though Pilsbry had some misgivings about his species, he did not realize the appropriateness of his trivial name. The type is regraded as the crushed corroded posterior end of a left valve of *L. mactropsis*. The illustration is enlarged about 2½ times.

L. mactropsis is similar to a living eastern Pacific species described by H. A. Rehder (unpub. data). which ranges from both sides of Baja California to northern Sinoloa, México. The species from the Gatun is somewhat smaller and has stronger sculpture, except the foliaceous sculpture. The unnamed species (length as great as 50 mm) has been confused with *L. kellettii* (Hinds) (Olsson, 1961, p. 296, pl. 41, fig. 5, figs. 4, 4a), a more southern species that is larger (length as great as 70 mm) and less foliaceous.

Eleven names have been proposed for close allies of *L. mactropsis* in the early to late Miocene of Florida. Many of them surely are synonyms, and some may be found to be synonyms of *L. mactropsis*.

Occurrence: Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, localities 138, 138a, 138c, 138d, 138e, 138f, 138h. Middle part, eastern area, localities 139c, 139e, 139f, 139g, 139h, 140, 142, 146, 147a, 147b, 147c, 147d, 147f, 147g, 147h, 150a, 151, 153, 153a, 155, 155a, 155b, 155c, 157, 158, 159d; western area, localities 160, 160d, 166, 169. Upper part, eastern area, localities 171, 172, 173a, 175, 176, 177a, 177b, 178; western area, localities 182, 183. Punta Carballo formation (early Miocene), Puntarenas Province, Costa Rica (Haas' record, locality needs confirmation). Middle Miocene deposits at Tuxtepec, Oaxaca, México; at San Andres Tuxtla, Veracruz, México. Middle Miocene deposits, Limón Province, Costa Rica; Río Changuinola district, Bocas del Toro area, Panamá; Darién, Panamá (USGS 8429 and other localities); Río Sínu area, Córdoba Dept., Colombia (USGS 11574). Hibachero and Tubará formations (middle Miocene), Atlántico Dept., Colombia. Middle(?) Miocene deposits south of Dabajuro, Falcón, Venezuela. Middle Miocene deposits, Chiriquí Province, Panamá (USGS 7955). Angostura formation (middle Miocene), Ecuador, Concepción formation (late Miocene), Tehuantepec area, México. Limónes formation (late Miocene), Bocas del Toro area, Panamá (USGS 8316 and other localities). Charco Azul formation (Pliocene), Chiriquí Province, Panamá (Olsson record).

Genus Nioche Hertlein and Strong

Hertlein and Strong, New York Zoological Soc., Zoologica, v. 33, pt. 4, p. 186, 1948.

Type (orthotype): *Venus asperrima* Sowerby, living, Gulf of California to northern Perú.

Subgenus Antinioche Olsson

Olsson, Mollusks of the tropical eastern Pacific; Panamic-Pacific Pelecypoda, p. 310, Paleontological Research Inst., 1961.

Type (orthotype): *Nioche* (*Antinioche*) *beili* Olsson, living, Panamá to Ecuador.

Keen (1971, p. 193) considered *Nioche* to be a synonym of *Leukoma* Römer, and *Leukoma* and *Antinioche* to be subgenera of *Protothaca* Dall. Olsson's simpler arrangement is preferred. In any event, *Antinioche* is a paciphile, and the following species is not only the first western Atlantic species to be described but also the only fossil species so far known.

Nioche (Antinioche) dolicha Woodring, n. sp.

Plate 119, figure 2

Of medium size, subelliptical, height 80 percent of length, moderately inequilateral, moderately convex. Both ends broadly rounded. Umbo low. Lunule not depressed, narrow, elongate, circumscribed by shallow groove, bearing concentric and radial sculpture like main part of shell. Escutcheon of left valve very narrow, devoid of sculpture, except faint growth lines; escutcheon of right valve unknown. Sculpture of low, narrow, moderately spaced concentric lamellae, slightly frilled by lower, narrow, closely spaced radial riblets in interlamellae. Right narrow anterior and wedge-shaped middle (but not posterior) cardinal teeth preserved on umbonal fragment. Left hinge unknown. Inner margin, including lunular margin, finely denticulate. Pallial line indistinct.

Length 41.7 mm, height 33.4 mm, convexity 8 mm (type).

Type (left valve): USNM 647629.

Type locality: 138d (USGS 22016, about 100 m north of Transisthmian Highway and about 75 m west of road to refinery site on Payardi Island, Panamá; immediately east of Cativa and 100 m north of locality 138), lower part of Gatun formation.

This *Periglypta*-like species is represented by the left-valve type and a right-valve umbonal fragment, both collected at the same locality, but at different times, in the lower part of the Gatun formation. It is more elongate, less inequilateral, and less convex than the living eastern Pacific type species of *Antinioche*, *Nioche beili* (Olsson, 1961, p. 310, pl. 50, figs. 1, 1a, 4).

Occurrence: Lower part of Gatun formation (middle Miocene), localities 138c, 138d.

Genus Anomalocardia Schumacher

Schumacher, Essai d'un nouveau système des habitations des vers testacés, p. 134, Copenhagen, 1817. Cited as of Klein.

Type (monotype): *Anomalocardia rugosa* [Schumacher] = *Venus flexuosa* Linné, more familiarly known as *Venus brasiliana* Gmelin, living, North Carolina to Uruguay.

Anomalocardia heothina Woodring, n. sp.

Plate 91, figures 1, 2

Small, trigonal-ovate, generally short, exceptionally elongate. Moderately to decidedly inequilateral, moderately convex. Anterior dorsal margin concave; posterior dorsal-lateral margin barely convex to practically straight. Posterior end more narrowly rounded than anterior, especially on elongate specimens. Umbo high, narrow. Lunule slightly depressed, narrow, circumscribed by shallow groove. Sculpture variable. Concentric rugae generally very narrow and closely spaced on entire shell, or apparently absent on parts of some shells; exceptionally wider and more widely spaced on dorsal half of shell. Hinge of right valve: short slender anterior, wider middle, long slender posterior cardinal teeth. Hinge of left valve and pallial sinus unknown. Inner ventral margin coarsely denticulate, inner dorsal margins finely denticulate.

Length 19.8 mm, height 15.2 mm, convexity about 4 mm (type). Length 21 mm, height 16 mm, convexity about 5 mm (paratype). Length 25.3 mm, height 21.2 mm, convexity (both valves) 14 mm (largest specimen).

Type (left valve): USNM 647740; paratype (left valve): USNM 647741.

Type and paratype locality: 42i (USGS 18845, Barro Colorado Island, eastern part of island, stream east of Shannon Trail, about 365 m southeast of Shannon 1, Canal Zone), Bohio formation.

Thirty-eight specimens of *Anomalocardia heothina* were collected from the Bohio formation on Barro Colorado Island, three of which at the type locality are articulated. Most of those from the type locality are more or less corroded or are internal molds, but almost all of those from locality 42f are preserved shells. All of 28 from that locality, however, are immature, ranging in length from 2.5 to about 10 mm.

This species is the earliest known *Anomalocardia.* It is variable in outline and sculpture. It is smaller than *A. flexuosa,* and even elongate specimens, such as those illustrated, have a less pointed posterior end than immature valves of the living species. No indication of subdued radial sculpture is apparent, but the corroded mature specimens are hardly suitable to show such sculpture.

Occurrence: Bohio formation (late Oligocene): localities 42f, 42i.

Subfamily GEMMINAE

Genus Parastarte Conrad

Conrad, Acad. Nat. Sci. Philadelphia Proc., 1862, p. 288.

Type (orthotype and monotype): *Estarte* (error for *Astarte*) *triquetra* C[onrad], living, Florida, to Bahamas, northern West Indies, and Quintana Roo, México.

At an early date, Dall (1902b) discussed the close relations of *Gemma* and *Parastarte.* Jukes-Brown (1913, p. 477) treated *Parastarte* as a subgenus of *Gemma,* an arrangement that was adopted by Palmer (1927, p. 208) and by Olsson and Harbison (1953, p. 119).

In addition to minor differences between the two taxa and although their ranges overlap, *Gemma* is a northern taxon, whereas *Parastarte* is southern. To be sure, both are recorded from the same locality in eastern Puerto Rico (Warmke and Abbott, 1961, p. 190). The distinction, however, is based on outline, which is variable. The USNM collections include lots of *Parastarte triquetra* from the Cayman Islands, Lago de Enriquillo, Dominican Republic, and Quintana Roo, México. At all the Caribbean localities, the hinge is more delicate than on mainland specimens.

Twenty-five poorly preserved minute specimens (maximum length 1.4 mm), recrystalized to calcite, from the La Boca formation at locality 101d are listed as *Parastarte*? sp., without any implication that they are the same species as the *Parastarte*? sp. from the marine rocks of late Eocene age.

Parastarte(?) species

Plate 90, figures 3, 4, 8, 9

Minute, subtrigonal to trigonal-ovate, equilateral or practically equilateral, strongly convex. Lunule not preserved or not apparent. Sculpture of more or less exaggerated growth lines, or poorly developed, crowded rugae. Hinge not preserved. No indication of denticulation on inner ventral margin.

Length 1.9 mm, height 1.8 mm (largest figured specimen).

Inasmuch as the hinge is unknown, this minute species may represent some other genus. The absence of denticulation on the inner ventral margin, however, does not rule out *Parastarte.*

This species occurs in the marine rocks of late Eocene age at the pre-canal Vamos Vamos locality (locality 40e) and at Palenquilla Point (locality 41). At both localities, numerous unextractable specimens of these fossils are scattered through the rock. At locality 41, they are preserved in the hard rock of a calcareous concretion and are more or less corroded. The Vamos Vamos collection was obtained from the weathered oxidized rock at the top of the section as it was exposed there in 1911. The specimens at that locality are crumbly internal molds.

If these fossils were *Parastarte,* they would be of interest as the earliest species of that genus in the Tertiary Caribbean province; indeed, no species of that genus have been recorded heretofore in the province. Harris (1919, p. 152, pl. 47, figs. 14, 15) described as *Gemma sanctimauricensis* the only Eocene gemmine on record. Though the locality ("Sabine River, Louisiana(?)" is doubtful, it has been attributed to the middle Eocene Cook Mountain formation (Palmer and Brann (1965, p. 149)). It is twice as large (height 3.5 mm) as the fossils from the marine rocks of late Eocene age.

Occurrence: Marine rocks of late Eocene age, localities 40e, 41.

Parastarte psila Woodring, n. sp.

Plate 116, figures 10, 13

Minute, low, trigonal-ovate, equilateral, slightly convex. Anterior dorsal-lateral margin and posterior dorsal-lateral margin about equally convex. Lunule not apparent. Sculpture of obscure growth lines. Hinge of right valve: short slender anterior, wider middle, and long, moderately slender posterior cardinal teeth. Hinge of left valve unknown. Pallial sinus indistinct. Inner ventral margin smooth.

Length and height 1.85 mm (type).

Type (right valve): USNM 647743.

Type locality: 138c (USGS 21956, about 100 m north of Transisthmian Highway and about 75 m west of road to refinery site on Payardi Island, Panamá; immediately east of Cativa and 100 m north of locality 138), lower part of Gatun formation.

Parastarte psila is represented by a right valve from the lower part of the Gatun formation. Though the hinge is typical for *Parastarte*, the low almost ovate outline and slight convexity are unique. This fossil is perhaps most similar to the middle Miocene Jamaican *P. antillensis* (Woodring, 1925, p. 164, pl. 22, figs. 11, 12) but is much less convex as well as much smaller, less trigonal, and the inner margin is smooth. The small size, absence of a lunule, and absence of denticulation, even on the anterior part of the inner ventral margin, suggest that the fossil from the Gatun is immature.

Occurrence: Lower part of Gatun formation (middle Miocene), locality 138c.

Family PETRICOLIDAE

Genus Petricola Lamarck

Lamarck, Systême des animaux sans vertèbres, p. 121, 1801.

Type (logotype Schmidt, Versuch über die beste Einrichtung * * * Vorzüglich der Conchylien-Sammlungen * * *, p. 55, 1818; not seen, quoted from Stewart, 1930, p. 33–35 and Winckworth, 1944): *Venus lapicida Chem*[*nitz*] (*Venus lapicida* Gmelin), cited by Lamarck in synonymy of *Petricola costata* n. sp., living, South Carolina to Rio Grande do Sul, Brasil.

Petricola millestriata Brown and Pilsbry

Petricola millestriata Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 64, p. 516, pl. 26, fig. 2, 1913 (Miocene, Canal Zone).

This species is not represented in the collections under study. The type, an internal mold, and an incomplete external mold, collected from the Gatun formation at the spillway of Gatun Dam, were available to Brown and Pilsbry. According to a written communication from Earl L. Shapiro, these specimens evidently have been lost or misplaced.

The description and illustration indicate that the species from the Gatun is less inequilateral than *Petricola lapicida* and its posterior end is more broadly rounded. *P. lapicida* is recorded from the Pliocene of Florida (Dall, 1890–1903, pt. 5, p. 1059, 1900) and Venezuela (Weisbord, 1964, p. 327, pl. 47, figs. 13, 14).

Length 27 mm, height 21 mm, convexity 7.5 mm (type, quoted from Brown and Pilsbry).

Occurrence: Middle part of Gatun formation (middle Miocene) spillway of Gatun Dam (Brown and Pilsbry's record).

Genus Rupellaria Fleuriau-Bellevue

Fleuriau-Bellevue, Jour. Physique, v. 54, p. 347, 1802.

Type (logotype, Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 5, p. 1058, 1900: *P*[*etricola*] *lithophaga* (Retzius) (*Venus lithophaga* Retzius) cited by Fleuriau-Bellevue in synonymy of his "Rupellaire reticulée," living, Mediterranean Sea, eastern North Atlantic Ocean, England to Gibraltar.

As a matter of fact, *Venus lithophaga* is the subjective monotype of *Rupellaria*, as both species cited by Fleuriau-Bellevue are regarded as synonyms of Retzius' species (Bucquoy, Dautzenberg, and Dollfus, 1887–98, p. 444, 1893).

Rupellaria typica (Jonas)

Plate 118, figure 2

Choristodon typicum Jonas, Zeitschr. für Malakozoologie, Jahrg. 1844, p. 185, November, 1844 (living, St. Thomas). Jonas, Hamburg Naturwissenschaftlichen Vereine, Abh. Gebiete Naturwissenschaften, v. 1, p. 2 (of separate), pl. 7, figs. 3, 3a, 1846 (living, St. Thomas).

Petricola (*Rupellaria*) *typica* (Jonas), Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 5, p. 1059, 1900 (Pliocene, Florida, living, West Indies). Weisbord, Bull. Am. Paleontology, v. 45, no. 204, p. 329, pl. 47, fig. 15, pl. 48, figs. 1–6, 1964 (Pleistocene, living, Venezuela; see this publication for additional citations).

Rupellaria typica (Jonas), Warmke and Abbott, Caribbean seashells, p. 191, pl. 44, fig. b, Narberth, 1961 (living, West Indies).

Petricola robusta Sowerby, Zoological Soc. London Proc., 1834, p. 47 (living, Panamá).

Petricola (*Petricola*) *robusta* Sowerby, Olsson, Mollusks of the tropical eastern Pacific; Panamic-Pacific Pelecypoda, p. 315, pl. 54, figs. 2, 2a 1961 (living, Gulf of California to northern Perú).

Petricola (*Rupellaria*) *riocanensis* Maury, Bull. Am. Paleontology, v. 5, no. 29, p. 220, pl. 37, fig. 12, 1917 (Miocene, Dominican Republic).

Of medium size, ovate, decidedly inequilateral, strongly convex. Anterior dorsal-lateral margin broadly convex; posterior dorsal-lateral margin straight. Posterior end much more narrowly rounded than anterior. Umbo low, wide. Lunulelike short, triangular depressed area under umbo. Sculpture of narrow, closely spaced radial riblets, spacing wider on posterior third of shell than elsewhere. Riblets slightly noded on ventral part of shell, especially on posterior ventral part, by irregularly spaced, more or less exaggerated growth lines. Hinge of left valve defective. Hinge of right valve unknown. Pallial sinus wide, semicircular.

Length (almost complete) 22.5 mm, height 19.6 mm, convexity 8 mm (figured left valve).

Type: Unknown.

Type locality: St. Thomas, West Indies.

A left valve from the upper part of the Gatun formation in the eastern area is identified as *Rupellaria typica*.

This species is living on both sides of Central America, although the eastern Pacific representatives are currently known as *R. robusta* (Sowerby).

Occurrence: Upper part of Gatun formation (middle Miocene), eastern area, locality 175.

Genus Pleiorytis Conrad

Conrad, Acad. Nat. Sci. Philadelphia Proc., 1862, p. 286.

Type (monotype): *P[leiorytis] ovata [Conrad]*, = *Petricola striata* Conrad, 1833, Miocene, Virginia and Maryland.

Gardner (1936, p. 39–40; 1943 [1944], p. 118–119) restored *Pleiorytis* to the family Petricolidae, where it had been placed by Conrad. Dall (1890–1903, pt. 5, p. 981, 1900) had assigned *Petricola striata* and its synonym *Pleiorytis ovata* to the psammobid genus *Asaphis*, and his lead had been followed.

Pleiorytis orthra Woodring, n. sp.

Plate 91, figure 4

Small, thin shelled, short-ovate, moderately inequilateral, strongly convex. Anterior dorsal-lateral margin strongly convex; posterior dorsal-lateral margin less strongly convex. Umbo low, narrow. Sculpture of very fine, closely spaced, somewhat vermicular radial threads. Regularly and fairly widely spaced, narrow concentric depressions ("resting stages") on ventral fourth of shell. Interior inaccessible.

Length 13.8 mm, height 10.5 mm, convexity about 4 mm (type).

Type (right valve) USNM 647746.

Type locality: 42d (USGS 18837, Barro Colorado Island, northern part of island, stream heading west of Miller Trail near Miller 17, about 100 m above mouth, Canal Zone), upper part of Bohio formation.

Though the right valve that is the type and only specimen of *Pleiorytis orthra* doubtless is immature, it is of special interest as the earliest known *Pleiorytis*. Heretofore, the genus was unknown before middle Miocene time. In outline, this small valve is similar to the much larger *P. caroniana* (Maury) (Vokes, 1938, p. 15, fig. 11; Jung 1969, p. 406, pl. 38, fig. 11; maximum length 57.5 mm), from the late Miocene Springvale formation of Trinidad.

Occurrence: Bohio formation (late Oligocene), locality 42d.

Family CORBULIDAE

Subfamily CARYOCORBULINAE

Genus Caryocorbula Gardner

Gardner, Nautilus, v. 40, p. 46, 1926.

Type (orthotype): *Corbula alabamiensis* Lea, Eocene, Alabama.

Two small internal molds from the marine rocks of late Eocene age (length 5–6 mm) and 11 minute specimens from the same unit are listed as *Caryocorbula* sp.

Poorly preserved corbulids of medium size (length of largest 11.2 mm) from the La Boca formation and the upper member of the Alhajuela formation also are listed as *Caryocorbula* sp.

Caryocorbula phruda Woodring, n. sp.

Plate 90, figures 23–25

Corbula (Cuneocorbula) alabamiensis Lea, Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 4, p. 841, 1898 (Eocene, Canal Zone).

Corbula alabamiensis Lea, Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 63, p. 371 1911 (Eocene, Canal Zone, Dall's record).

Corbula (Caryocorbula) alabamiensis Lea, Clark, *in* Clark and Durham, Geol. Soc. America Mem. 16, p. 75, pl. 13, figs. 8, 11, 12, 15, 16, 1946 (Eocene, Colombia).

Of medium size, elongate-ovate, practically equilateral, moderately convex. Right and left valves of about same size and convexity. Posterior dorsal area narrow, set off by subdued angulation. Posterior end pointed or somewhat pointed. Sculpture of moderately fine concentric rugae. Some valves show faint radial sculpture. Resilifer of left valve large, thick, dorsal surface not concave. Interior of right valve inaccessible.

Length 15 mm, height 9 mm, convexity 5 mm (type). Length 15 mm, height 10.4 mm, convexity about 6 mm (paratype). Length 16.7 mm, height 10 mm, convexity 6 mm (largest specimen).

Type (left valve): USNM 647748; paratype (right valve): USNM 647749.

Type locality: 40d (USGS 6028a, Vamos Vamos, lower bed, collected by D. F. MacDonald and T. W. Vaughan, 1911), marine rocks of late Eocene age. Paratype locality: 40a (USGS 2683, same locality as type locality, collected by R. T. Hill, 1895).

Though Dall recorded *Corbula alabamiensis* from the alleged "Gatun beds" of the Canal Zone, the labels he wrote for these fossils specified only *Corbula*. All were collected at Vamos Vamos, not from the Gatun formation.

Dall's *C. alabamiensis* is now described as *Caryocorbula phruda* on the basis of 25 valves from the marine rocks of late Eocene age. It is indeed closely related to *C. alabamiensis*, which is abundant in the middle Eocene Gosport sand at Claiborne, Alabama (Harris, 1919, p. 185, pl. 56, figs. 16–26). The Canal Zone fossils are somewhat smaller than *C. alabamiensis*, and six of them show faint radial sculpture, a feature not observed on shells from the Claiborne. The chief difference, however, lies in the larger and thicker resilifer of the left valve of *C. phruda*. Unfortunately, the type of that species is the only specimen that shows the interior of the left valve. Whether Colombian specimens have a comparable resilifer is not known.

Occurrence: Marine rocks of late Eocene age localities 40, 40a, 40d, 40e, 41, 41b. Late Eocene part of Carmen formation, Bolívar Dept., Colombia.

Caryocorbula platys Woodring, n. sp.

Plate 91, figure 3

Corbula (*Cuneocorbula*) *alabamiensis* Lea, Joukowsky, Soc. Phys. Hist. Nat. Geneva Mem., v. 35, p. 163 (list), 173, pl. 6, figs. 24, 25, 1906 (Oligocene, Panamá).

Of medium size, elongate-ovate, slightly inequilateral, moderately convex. Right valve slightly larger than left. Posterior dorsal area moderately narrow, set off by subdued angulation. Posterior end pointed. Sculpture of fairly coarse concentric rugae on ventral two-thirds of shell. Interior inaccessible.

Length 12.6 mm, height 7.8 mm, convexity (both valves, reduced by crushing) 4 mm (type).

Type (articulated specimen): USNM 647750.

Type locality: 42f (USGS 18836, Barro Colorado Island, northern part of island, stream southeast of Fuertes House, about 335 m above mouth, from slide on west side of stream, Canal Zone), upper part of Bohio formation.

Eight specimens of *Caryocorbula platys* were collected from the upper part of the Bohio formation on Barro Colorado Island. The type is the only one in good condition, and it is somewhat crushed laterally.

This species occurs also in the Santiago area of the Azuero Peninsula. The larger of two valves from that area (length 9.7 mm) is somewhat smaller than the type.

Occurrence: Bohio formation (late Oligocene), localities 42d, 42f, 42g. Late Oligocene deposits, Santiago area, Panamá (USGS 8468).

Caryocorbula oropendula stena Woodring, n. subsp.

Plate 119, figures 22–24

Corbula (*Cuneocorbula*) *gregorioi* Cossmann, Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 4, p. 843, 1898 (Miocene, Canal Zone).

Corbula gregorioi Cossman, Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 63, p. 372, 1911 (Miocene, Canal Zone, Dall's record).

Corbula sericea Dall, Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 63, p. 371, 1911 (Miocene, Canal Zone).

Corbula aff. *carinata* Duj[ardin], Toula, K. k. Geol. Reichsanstalt Jahrb., v. 61, p. 496 pl. 31, fig. 7, 1911 (Miocene, Canal Zone).

Small, ovate, height slightly less than length, slightly inequilateral, strongly convex. Right valve slightly larger than left. Posterior dorsal area moderately narrow, set off by subdued angulation. Ventral margin slightly insinuated in front of posterior angulation, most pronounced on mature shell. Sculpture of fine concentric rugae; umbonal part devoid of sculpture. Some valves show scattered fine radial sculpture. Right cardinal tooth and left resilifer small, commensurate with size of shell.

Length 6.1 mm, height 4.7 mm, convexity 2.4 mm (type). Length 5.6 mm, height 5 mm, convexity (both valves) 4.2 mm (paratype).

Type (right valve) USNM 647751; paratype (articulated specimen): USNM 647752.

Type locality: 147b (USGS 6033c, Panama Railroad, about 3,500 feet (1,065 m) southeast of Gatun railroad station, Canal Zone), middle part of Gatun formation. Paratype locality: 155b (USGS 16949, Gatun Third Locks, Canal Zone), middle part of Gatun formation.

This small *Caryocorbula* ranges through the Gatun formation, except in the upper part in the western area. It is locally abundant, especially at locality 138c in the lower part of the formation and at localities 139b, 139c and 147b in the middle part, at all of which about 100 were collected. About 500 are estimated to be available.

All specimens of the nominate subspecies illustrated by Olsson have been catalogued as syntypes (Brann and Kent, 1960, p. 267–268). Olsson (1922, p. 268), however, wrote that he chose as the type the form found on Río Banano, but he failed to do so. In view of his intention, the left valve from Río Banano shown on his plate 28, figures 13 and 27, is herewith designated the lectotype. (The catalogue corrects locality errors in the expanation of the plate.) Many virtual topotypes are in USNM collections from Río Banano. They are consistently elongate (length 6.5 mm, height 4.2 mm) and have weaker and coarser sculpture than the subspecies from the Gatun.

Dall identified as *Corbula gregorioi* Cossman (a small equilateral middle Eocene *Caryocorbula* from Alabama and other Gulf States) 17 specimens of *Caryocorbula oropendula stena* from locality 173a. They were collected by R. T. Hill in 1895. Though the locality record reads 10.5 km from Colón, they surely were collected at Monkey Hill (Mount Hope of present terminology), as that was the only place at that time where perfectly preserved fossils were available from the Gatun.

C. sericea (Dall, 1890–1903, pt. 4, p. 848, 1898; pt. 5, pl. 36, fig. 8, 1900) was the earliest small Miocene species from the Caribbean region to be described. The type lot was collected by R. T. Hill in 1895 from the Limónes formation of Costa Rica, which is considered to be of late Miocene age. It is slightly smaller than *C. oropendula stena* (length 5.5 mm), has a lower umbo, and is more consistently radially sculptured.

More or less similar small Miocene species of *Caryocorbula* are abundant in the Alum Bluff group of Florida. Some are even smaller than *C. oropendula* and *C. sericea*.

C. cercadica Maury (1917, p. 232, pl. 39, figs. 16, 17), which is extraordinarily abundant in the Cercado formation of the Dominican Republic at the type locality of the species on Río Mao, is slightly larger than *C. oropendula* and has the barest suggestion of an insinuated ventral margin.

Occurrence: Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, localities 136, 136a, 137, 138, 138a, 138c, 138d, 138e, 138f. Middle part, eastern area, localities 139b, 139c, 139d, 139e, 139f, 147b, 147e, 147f, 147g, 147h, 152, 153, 153a, 155, 155a, 155b, 155c, 159d; western area, localities 161, 161a, 161b, 161d, 166, 169. Upper part, eastern area, localities 172, 173, 173a, 177c, 177d.

Caryocorbula oropendula dolicha Woodring, n. subsp.

Plate 119, figures 4–6

Small, elongate-ovate, height less than length, slightly inequilateral, convexity strong or moderately strong. Right valve slightly larger than left. Posterior dorsal area moderately narrow, set off by fairly strong angulation. Sculpture of fine concentric rugae; umbonal part devoid of sculpture. Hinge like that of preceding subspecies.

Length 6.9 mm, height 4.6 mm, convexity 2.5 mm (type). Length 6 mm, height 4.4 mm, convexity (both valves) 2.3 mm (paratype).

Type (right valve): USNM 647753; paratype (articulated specimen): USNM 647754.

Type and paratype locality: 185 (USGS 8383, Caribbean coast, west of San Miguel [Río Miguel], station 26 plus 100 feet (30 m), Panamá), upper part of Gatun formation.

In the upper part of the Gatun formation in the western area, *Caryocorbula oropendula stena* is replaced by *C. oropendula dolicha*. It is abundant at the type locality: about 200 specimens.

The elongate-ovate outline is like that of the nominate subspecies, but the sculpture is like that of *C. oropendula stena*. The posterior angulation is somewhat stronger than that of the other two subspecies, and the ventral margin is not insinuated.

Occurrence: Upper part of Gatun formation (middle Miocene), western area, localities 183, 185.

Caryocorbula cf. C. manzanillensis (Maury)

Very small, ovate-elongate, height less than length, inequilateral, moderately convex. Right valve slightly larger than left. Posterior dorsal area moderately wide, set off by angulation, generally sharp. Sculpture of fine concentric rugae, indistinct on umbonal area.

Length 5.5 mm, height 4 mm, convexity 1.5 mm.

Nine specimens from the Gatun formation at Mount Hope, four of which are articulated, are identified as *Caryocorbula* cf. *C. manzanillensis* (Maury, 1925a, p. 257, pl. 20, figs. 6, 7). In size, outline, and concentric sculpture they closely resemble *C. manzanillensis* but show no indication of radial sculpture. In size they are similar to *C. sericea*, discussed under *C. oropendula stena*. The fossils from Mount Hope, however, have slightly finer concentric sculpture and lack radial sculpture.

Occurrence: Upper part of Gatun formation, western area (middle Miocene) locality 177b.

Caryocorbula prenasuta Olsson

Plate 120, figures 7, 8, 13

Caryocorbula (*Caryocorbula*) *prenasuta* Olsson, Neogene mollusks from northwestern Ecuador, Paleontological Research Inst., p. 70, pl. 9, fig. 10, 1964 (Miocene, Ecuador).

Of medium size, elongate-ovate (except some small, short-ovate valves), practically equilateral, strongly convex. Thick-shelled or shell of moderate thickness. Right valve slightly larger than left. Posterior dorsal area moderately narrow, set off by generally sharp angulation. Sculpture of strong concentric rugae of varying width and spacing, generally closely spaced. Right cardinal tooth strong, triangular. Interior cavity deep, elliptical, heavily margined.

Length 16.8 mm, height 9.5 mm, convexity 5.5 mm (illustrated right valve).

Type (right valve): USNM 644238.

Type locality: Cueva de Angostura, Río Santiago, Ecuador, Angostura formation.

Caryocorbula prenasuta occurs in the lower and middle parts of the Gatun formation: 69 specimens, 77 percent of which were found in the lower part. All of 31 specimens from localities 136 and 136a (two collections from the same locality in the lower part) are relatively small (pl. 120, fig. 13). Two small valves from localities 144c and 144d, the only specimens from those localities, are small, short-ovate, and coarsely sculptured (length 10 mm, height 6 mm).

This species is closely related to *C. orosi* (Olsson, 1922, p. 269, pl. 21, figs. 9, 10; Miocene, Costa Rica), which is larger and has a less sharply demarked posterior area. *C. nasuta* (Sowerby) (Olsson, 1961, p. 429, pl. 75, figs. 3–3e) typically has a snoutlike posterior extension and fine radial sculpture.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, localities 136, 136a, 138b, 138c, 138d, 138f, 138g. Middle part, eastern area localities 139 (*Caryocorbula* sp.). 139c, 140, 144c, 144d, 155a; western area, localities 161c, 169. Angostura formation (middle Miocene), Ecuador.

Genus Bothrocorbula Gabb

Gabb, Acad. Nat. Sci. Philadelphia Proc., p. 274, 1872.
Type (monotype): *Corbula viminea* Guppy, Miocene, Jamaica, Dominican Republic, Costa Rica.

Subgenus Hexacorbula Olsson

Olsson, Bull. Am. Paleontology, v. 19, no. 68, p. 140, 1932.
Type (orthotype): *Corbula hexacyma* Brown and Pilsbry = *C. gatunensis* Toula, Miocene, Canal Zone and other localities in Miocene Caribbean province.

In general outline and sculpture, *Hexacorbula* is similar to *Bothrocorbula* but lacks the lunular pit of *Bothrocorbula*. In addition, the ventral margin of the valves of *Hexacorbula* is typically bent inward almost at a right angle.

Hexacorbula is a paciphile subgenus. Its age range in western Atlantic waters is early to late Miocene. It survives in the eastern Pacific Ocean: "*Caryocorbula*" (*Hexacorbula*) *esmeralda* (Olsson, 1961, p. 432, pl. 76, figs. 3–3c), dredged off Ecuador at depths of about 20 feet (6 m). The type lot of that species consists of two right and two left valves. A left valve (Olsson, 1961, fig. 3b, length 22.4 mm) has the ventral margin bent inward, but the margin so bent is narrower than on valves of *B. gatunensis* of the same size.

An exterior mold of a right valve from the upper member of the Alhajuela formation at locality 89 (length about 12 mm) is listed as *Bothrocorbula* (*Hexacorbula*) sp.

Bothrocorbula (Hexacorbula) cruziana (Olsson)

Plate 93, figure 3; plate 98, figure 11

Corbula (*Hexacorbula*) *cruziana* Olsson, Bull. Am. Paleontology, v. 19, no. 68, p. 141, pl. 3, fig. 5, pl. 4, fig. 9, 1932 (Miocene, Perú).

Very small to moderately small, exceptionally of medium size. Elongate-ovate to short-ovate. Elongate-ovate valves have an elongate pointed posterior end. Practically equilateral, moderately convex. Posterior area moderately narrow, set off by subdued angulation. Umbo low, narrow. Extreme ventral part of valve bent inward almost at right angle. Sculpture absent in umbonal area. Remainder of valve sculptured with four to six low undulations, reduced in width and strength addorsally, fine growth lines on and between undulations. Faint radial sculpture discernible on umbonal part of one valve.

Length 10.3 mm, height 5.7 mm, convexity 3.5 mm (figured right valve from Culebra formation). Length 11 mm, height 8.5 mm, convexity 3.2 mm (figured left valve from La Boca formation).

Type (left valve): Paleontological Research Inst. 2172; paratype (right valve): Paleontological Research Inst. 2183.

Type locality: Zapotal, Zorritos district, Perú, lower part of Zorritos formation. Paratype locality: Quebrada La Cruz, Zorritos district, Perú, lower part of Zorritos formation.

Fifty-five specimens from the Culebra formation and an estimated 450 from the La Boca formation are identified as *Bothrocorbula cruziana*. The range of variation in size and outline, however, is much greater than in the type area of that species. All of an estimated 120 in the La Boca from locality 99b and small lots from both formations are very small (length 6 or 7 mm). Elongate-ovate valves, like that from the Culebra shown on plate 93, figure 3, have an elongate pointed posterior end. The illustrated valve from the La Boca (pl. 98, fig. 11) is the only short-ovate specimen of medium size. It is considerably smaller than *B. cruziana* in the type area, where the latter specimen reaches a length of 17 mm.

The inward-bent extreme ventral part of the valve, commensurate with the small size of the species, is very narrow.

This is the earliest known *Hexacorbula*.

Occurrence: Culebra formation (early Miocene), localities 107a, 110, 110a, 111a, 111b, 112, 112a, La Boca formation (early Miocene), Gaillard Cut area, localities 99b, 99f, 100, 100a, 100b, 114, 115, 115b, 116a). Lower part of Zorritos formation (early Miocent), Perú.

Bothrocorbula (Hexacorbula) gatunensis (Toula)

Plate 121, figures 1, 2, 4–6

Corbula gatunensis Toula, K. k. Geol. Reichsanstalt Jahrb., v. 58, p. 733, pl. 27, figs. 12 (2 illustrations), 1909 (Miocene, Canal Zone). Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 63, p. 371, 1911 (Miocene, Canal Zone). Olsson, Bull. Am. Paleontology, v. 9, no. 39, pl. 21, fig. 7, not in text, 1922 (Miocene, Canal Zone).

Corbula (Aloidis) gatunensis Toula, Hodson and Hodson, Bull. Am. Paleontology, v. 16, no. 59, p. 27, pl. 11, fig. 7, 1931 (Miocene, Venezuela).

Corbula (Bothrocorbula) viminea Guppy, Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 4, p. 850 (part), 1898 (Miocene, Canal Zone).

Corbula viminea Guppy, Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 63, p. 372, 1911 (Miocene, Canal Zone, Dall's record).

Corbula (Cuneocorbula) hexacyma Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 64, p. 518, pl. 26, fig. 4, 1913 (Miocene, Canal Zone). Weisbord, Bull. Am. Paleontology, v. 14, no. 54, p. 25, pl. 5, figs. 7–9, 1929 (Miocene, Colombia). Barrios, Colombia Servicio Geol. Nac. Bol. Geol., v. 6, nos. 1–3 (Informe 1082), p. 259, pl. 7, figs. 8, 9, 1960 (Miocene, Colombia).

Corbula hexacyma Brown and Pilsbry, Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 269, pl. 21, figs. 12, 13, 1922 (Miocene, Canal Zone).

Aloidis hexacyma (Brown and Pilsbry), Oinomikado, Geol. Soc. Japan Jour., v. 46, p. 629, pl. 29, fig. 24, 1939 (Miocene, Colombia).

Hexacorbula hexacyma (Brown and Pilsbry), Vokes, Am. Mus. Nat. History Bull., v. 86, art. 1, p. 13, pl. 1, figs. 21–23, 1945 (Miocene, Canal Zone).

Caryocorbula (Hexacorbula) hexacyma (Brown and Pilsbry), Olsson, Neogene mollusks from northwestern Ecuador, Paleontological Research Inst., p. 71, pl. 9, figs. 11–13, 1964 (Miocene, Ecuador).

Corbula (Caryocorbula) buenavistana F. Hodson, *in* Hodson and Hodson, Bull. Am. Paleontology, v. 16, no. 59, p. 24, pl. 8, fig. 6, pl. 12, figs. 8–13, 1931 (Miocene, Venezuela).

Moderately large, moderately thick shelled, ovate, height less than length, equilateral or slightly inequilateral, strongly convex. Posterior area narrow, set off by subdued angulation. Umbo low, narrow. Divided into two groups on basis of sculpture: (1) sculpture normal, like that of *C. hexacyma*; (2) sculpture abnormal, like that of *C. gatunensis*. In both groups, concentric sculpture absent in umbonal part, except worn growth lines, fine growth lines on and between concentric undulations, and faint radial sculpture generally discernible on dorsal part of valve beyond umbonal part. Growth lines strongest and sublamellar on posterior area. Right cardinal tooth large, swollen, triangular, tip under umbo.

Group 1. Posterior end drawn out into narrow, snoutlike extension, or extension shorter and pointed. Snoutlike extension obscurely tripartate. Ventral margin of valve bent inward almost at right angle, and smooth, except for growth lines. Sculpture of wide and widely spaced concentric undulations, reduced in width and strength addorsally, generally five to seven, exceptionally as many as nine.

Group 2. Posterior extension short, pointed. Ventral margin not bent inward. Sculpture of dorsal half (except extreme umbonal part), or more or less, consisting of 10 to 12 narrow and narrowly spaced concentric undulations. Ventral half, or more or less, flat or slightly warped, bearing growth lines, or narrow, closely spaced rugae. The two types of sculpture separated by sharp discontinuity.

Length 24.4 mm, height 17.8 mm, convexity (both valves) 17.6 mm (type of *Corbula gatunensis*, quoted from Toula). Length 18.7 mm, height 11 mm, convexity 4.8 mm (type of *C. hexacyma*, quoted from Brown and Pilsbry).

Type of *Corbula gatunensis* (left valve): Paläontologisches Inst., Univ. Wien; type of *C. hexacyma* (right valve): formerly at Academy of Natural Sciences, Philadelphia, now lost or misplaced.

Type locality of *C. gatunensis:* presumably Gatun Locks excavation, Canal Zone, middle part of Gatun formation. Type locality of *C. hexacyma:* Lower Gatun Locks excavation, Canal Zone, middle part of Gatun formation.

The corbulid designated as *Bothrocorbula (Hexacorbula) gatunensis* was found in the three parts of the Gatun formation but is rare in the upper part in the eastern area (one specimen) and is absent in the upper part in the western area. It is extraordinarily abundant in the lower part at the locality near Cativa, where two collections made at different times and by different collectors are listed as localities 138c and 138d: 296 and 190 specimens, respectively.

Of the 633 specimens that are of sufficient size to show the difference in sculpture, 630, including all the 570 from the lower part of the Gatun, have what is termed normal sculpture. Three have what is termed abnormal sculpture. On two of them, including that illustrated on plate 121, figure 1, and also on Olsson's and Hodsons' illustrated valves identified by them as *Corbula gatunensis*, the ventral margin is not bent inward, although the inward bending is regarded as a diagnostic feature of *Hexacorbula*. That *C. gatunensis* and *C. hexacyma* represent different species is highly improbable. For that reason, *Bothrocorbula (Hexacorbula) gatunensis*, which unfortunately has precedence over *B.(H.) hexacyma*, is adopted as the name of the species.

Vokes' illustrated valve of *Hexacorbula hexacyma* is immature (length 7.1 mm). It is one of four from locality 144d, two of which are minute (length 3.3 and 3.7 mm)—the only available minute shells.

Occurrence: Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, localities 138, 138a, 138b, 138c, 138d, 138e, 138f, 138g. Middle part, eastern area, localities 139c, 139g, 142, 144d, 147, 150, 151, 155, 155b, 155c, 158; western area, localities 161, 168, 169. Upper part, eastern area, locality 177e. Middle Miocene deposits, Río Sinú area, Corboda Dept., Colombia (USGS 1301); Jesus del Monte-Zambrano area, Bolívar Dept., Colombia; Tubará formation, Atlántico Dept., Colombia (USGS 11522); Choco Dept., Colombia. Middle Miocene deposits, Darién (USGS 8477). Angostura formation (middle Miocene), Ecuador. Limónes formation (late Miocene), Bocas del Toro area, Panamá. Presumably La Vela formation (late Miocene), Falcón, Venezuela.

Genus Varicorbula Grant and Gale

Grant and Gale, San Diego Soc. Nat. History Mem., v. 1, p. 420, footnote, 1931.

Type (orthotype): *Corbula gibba* (Olivi), living, eastern North Atlantic Ocean, Norway to Canary Islands, Mediterranean Sea.

The basic plan of the species of *Varicorbula* is similar from Eocene to the present time.

Notocorbula (Iredale, 1930a, p. 404; type (orthotype): *Notocorbula vicaria* Iredale, living, New South Wales, Australia), also has been used for this genus, but until the type species is better known, *Varicorbula* is preferred.

All the following species have similar generic features. Right valves are larger than left. The valves are discrepant in outline and sculpture. Right valves are trigonal-ovate, and left valves are elongate-ovate. Left valves generally lack a posterior area. The umbonal part of both valves is devoid of sculpture. The concentric undulations of right valves are reduced in width and spacing addorsally. Left valves have a few very widely spaced, fine radial threadlets or lack radial sculpture.

A large right valve (length 17.7 mm, height 15.7) from the La Boca formation and three minute right valves from the upper member of the Alhajuela formation are listed as *Varicorbula* sp.

Varicorbula baea Woodring, n. sp.

Plate 90, figures 19, 20

Very small.

Right valve, height slightly less than length, practically equilateral, strongly convex. Posterior area very narrow, set off by subdued angulation. Umbo very high, wide. Anterior margin slightly extended; posterior margin subtruncated. Sculpture of narrow, closely spaced undulations. Interior inaccessible.

Left valve, height less than length, slightly inequilateral, moderately convex. Posterior area very narrow, obscurely set off. Umbo low, moderately wide. Sculpture not well preserved, consisting of corroded, low, closely spaced concentric threads. No indication of radial sculpture. Interior inaccessible.

Right valve, length (incomplete) 3.6 mm (estimated restored length 4.2 mm), height 3.9 mm, convexity 2.4 mm; left valve, length 3.6 mm, height 2.7 mm, convexity 1.5 mm (type).

Type (articulated specimen): USNM 647762.

Type locality: 42 (USGS 17692, northeast coast of Trinidad Island, sandy siltstone, basal 3 m of exposed section, Canal Zone), marine rocks of late Eocene age.

This very small species is represented by 17 specimens, four of which, including the type, are articulated. It is even smaller than *Varicorbula laqueata* (Casey, 1903, p. 261), an Oligocene species from Mississippi, and also differs from that species in outline and coarser sculpture. *V. hodsoni* (Clark, *in* Clark and Durham, 1946, p. 74, pl. 13, figs. 1–7, 9), the only Eocene species of the genus on record from the Caribbean region, is about twice as large as *V. baea* and has very coarse undulations on the right valve and radial sculpture on the left.

Occurrence: Marine rocks of late Eocene age, locality 42.

Varicorbula cf. V. vieta (Guppy)

Plate 98, figure 6

Of medium size.

Right valve, height slightly less than length, slightly inequilateral, strongly convex. Posterior area very narrow, set off by subdued sculpture or its absence. Umbo high, wide. Anterior margin not extended. Sculpture of narrow, closely spaced concentric undulations. Interior inaccessible.

Left valve unknown.

Length 7.6 mm, height 6.5 mm, convexity 5 mm (figured right valve). Length 9.1 mm, height 6.9 mm, convexity about 4 mm (largest specimen).

The La Boca formation yielded 24 poorly preserved right valves of a *Varicorbula*. It is somewhat smaller than *V. vieta*, more trigonal, and has finer sculpture.

The type lot of *V. vieta* (Guppy, 1866, p. 580, pl. 26, fig. 8) is from the late middle Miocene Manzanilla formation of Trinidad. As has been known for many years (Guppy and Dall, 1896, p. 329), Guppy (1866, p. 582, pl. 26, fig. 6) described the left valve as *Erycina tensa*.

C. vieta has been identified in the early Miocene Pirabas formation of Brasil (Ferreira and Cunha, 1959, p. 33, pl. 3, figs. 1a, 1b).

Occurrence: La Boca formation (early Miocene), Gaillard Cut area, localities 99b, 99c, 99f, 101i.

Varicorbula disparilis (d'Orbigny), small form

Plate 124, figures 5–8

Corbula disparilis d'Orbigny, Mollusques, in de la Sagra, Ramon, Histoire physique, politique, et naturelle de l'île de Cuba, French ed., v. 2, p. 322, 1853(?), Atlas, 1842, pl. 27, figs. 1–4. For dates see Keen, 1971, p. 1006 (living, West Indies).

Corbula (Aloidis) heterogena Guppy, in Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 4, p. 850, 1898 (part, Miocene, Canal Zone); pt. 5, pl. 36, fig. 15, 1890.

Corbula heterogena Guppy, Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 63, p. 372, 1911 (Miocene, Canal Zone, Dall's record).

Corbula vieta Guppy?, Olsson, Bull. Am. Paleontology, v. 9, no. 39, p. 266 (assigned to section *Aloidis*), pl. 28, figs. 15, 16, 1922 (Miocene, Costa Rica).

Corbula waltonensis Gardner, U.S. Geol. Survey Prof. Paper 142–E, p. 229, pl. 34, figs. 18–21, 1928 (Miocene, Florida).

Small to medium size.

Right valve generally widely trigonal-ovate, but including narrowly trigonal-ovate shells. Height about equal to length, or slightly more or slightly less than length, practically equilateral. Strongly convex. Posterior area not distinguishable. Umbo high, wide. Anterior ventral margin rounded; posterior ventral margin very slightly extended, subtruncated. Sculpture of closely spaced concentric undulations, variable in width and spacing, but generally moderately narrow and moderately closely spaced. Cardinal tooth subtriangular, thin, set at slight angle to dorsal hinge margin.

Left valve, height slightly less than length, moderately inequilateral, moderately convex. Umbo moderately high, moderately wide. Both ends rounded, posterior more broadly than anterior. Sculpture of growth lines; generally a few very widely spaced, fine radial threadlets on dorsal part of valve. Threadlets distinct, or obscure, or none at all. Resilifer thin, slightly or moderately extended upward.

Length 6.8 mm, height 6.2 mm, convexity 3.5 mm (figured right valve, largest specimen). Length 4.9 mm, height 4.0 mm, convexity 1.6 mm (figured left valve).

A species of *Varicorbula*, identified as a small form of the living West Indian *V. disparilis*, is widespread in the Gatun formation, especially in the middle part of the formation. About 700 specimens are estimated to be available, but about 70 percent were collected at localities 147b and 147g in the middle part. It is rare in the lower and upper parts of the formation. It is smaller than lots of small *V. disparilis* dredged off Florida and the West Indies. Though greatly outnumbered by right valves, left valves are common. Articulated specimens are not unusual.

As shown by the illustrations of right valves (pl. 124, figs. 6, 8), the posterior area is unrecognizable. At other localities, however—for example, in the Limónes formation of the Bocas del Toro area—some right valves, also identified as the same small form of *V. disparilis*, have recognizable, although faint, posterior areas.

Since Dall's day, this *Varicorbula* from the Gatun has been identified as *V. heterogena*. The lectotype of that species, herewith designated, is the right valve, from the "shell bed" at Bowden, Jamaica, illustrated in interior view by Dall. *V. heterogena* is somewhat larger (length 7.5 or 8 mm) than the fossils from the Gatun. The posterior area generally is distinctly set off by subdued sculpture and subdued angulation. (Some of the many topotypes, however, show only slightly reduced sculpture and no angulation). The resilifer of the left valve is thick and is strongly extended upward (Woodring, 1925, pl. 26, figs. 3, 4). Perhaps *V. heterogena* is to be treated as a form of *V. disparilis*.

D'Orbigny's illustrations (1842, p. 322, pl. 27, figs. 1–4) are far from satisfactory for West Indian shells. Taxonomists who doubt that his publication predates 1848 use *Corbula operculata* (Philippi, 1848, p. 13, living, St. Thomas) for his species.

Occurrence: Lower, middle, and upper parts of Gatun formation (middle Miocene). Lower part, localities 138, 138a, 138c, 138g. Middle part, eastern area, localities 139b, 139c, 139e, 139g, 139h, 146, 147b, 147f, 147g, 147h, 151, 153a, 155a, 155c, 158, 159d; western area, localities 166, 169, 170a. Upper part, eastern area, localities 171, 174; western area, localities 183, 185. Middle Miocene deposits, Limón Province, Costa Rica; Darién, Panamá (USGS 8503). Oak Grove sand member of Shoal River formation and Shoal River formation proper (middle Miocene), Florida. Limónes formation (late Miocene), Limón Province, Costa Rica (USGS 21035); Bocas del Toro area, Panamá. Moín formation(late Pliocene), Limón Province, Costa Rica (USGS 5884b, 18692). Pliocene deposits, Bocas del Toro area, Panamá (USGS 8346).

Varicorbula islatrinitatis (Maury)

Plate 120, figures 1, 3, 9, 10

Corbula (*Aloidis*) *isla-trinitatis* Maury, Bull. Am. Paleontology, v. 10, no. 42, p. 101, pl. 19, figs. 1, 8–10, 1925 (Miocene, Trinidad).

Notocorbula islatrinitatis (Maury), Jung, Bull. Am. Paleontology, v. 55, no. 247), p. 411, pl. 40, figs. 1, 2, 1969 (Miocene, Trinidad).

Corbula (*Corbula*) *carrizalana* F. Hodson, *in* Hodson and Hodson, Bull. Am. Paleontology, v. 16, no. 59, p. 23, pl. 10, figs. 4, 6–9, 1931 (Miocene, Venezuela).

Large.

Right valve, generally narrowly trigonal-ovate, height slightly less than length, slightly inequilateral, strongly convex. Posterior area narrow, set off by subdued sculpture and faint angulation. Umbo very high, very wide. Anterior ventral margin rounded, not extended; posterior ventral margin slightly extended, truncated. Sculpture of low, very narrow, closely spaced undulations. Cardinal tooth wide, triangular, anterior face excavated, set at angle of about 45° to dorsal hinge margin.

Left valve height less than length, moderately inequilateral, moderately convex. Exterior for most part exfoliated, but traces of growth lines and a few very widely spaced radial threadlets visible on some valves, or such features preserved on part of valve. Resilifer thick, moderately extended upward.

Length 13.3 m, height 13 mm, convexity 8.3 (figured right valve). Length 8.9 mm, height 7 mm, convexity 2.5 mm (figured left valve). Length 18.1 mm, height 16.1 mm, convexity 9.5 mm (lectotype).

Type (lectotype, right valve represented by Maury's fig. 9: Paleontological Research Institute 909.

Type locality: Mt. Pleasant Quarry, 5,100 feet (1.5 km) north-northeast of Forres Park sugar mill, near Savaneta, Trinidad, Savaneta glauconitic sandstone member of Springvale formation.

Varicorbula islatrinitatis, represented by 93 specimens from the middle part of the Gatun formation, is by far the largest species of the genus in the faunas under consideration. Though it occurs in the same part of the Gatun as the small form of *V. disparilis*, it was not found to be associated with that species.

As it occurs in the Savaneta glauconitic sandstone member of the Springvale formation, *V. islatrinitatis* reaches a larger size than the fossils from the Gatun (length as much as 19 mm). The lectotype, designated by Jung, has a slightly extended posterior ventral margin, like right valves from the Gatun, but the smaller right valve (length 13.6 mm) from the Melajo clay member of the Springvale illustrated by Jung lacks the extension. Venezuelan specimens are comparable in size with those from Panamá.

V. bradleyi (Nelson, 1870, p. 200; Spieker, 1922, p. 171, pl. 10, figs. 13, 14; late Miocene, Perú) is another large species. According to Spieker's illustration of the type and only specimen, it is decidedly inequilateral.

Occurrence: Middle part of Gatun formation (middle Miocene), eastern area, localities 140, 144c, 144d, 150, 155, 155b. Presumably La Vela formation (late Miocene), Falcón, Venezuela). Savaneta glauconitic sandstone member and Melajo clay member of Springvale formation (late Miocene), Trinidad.

Family HIATELLIDAE

Genus Panopea Menard de la Groye

Ménard de la Groye, Mus. Hist. Nat. [Paris] Annales, v. 9, p. 135, pl. 12, 1807.

Type (logotype, Schmidt, Versuch über die beste Einrichtung * * *, p. 47, 177, Gotha, 1818 (not seen, quoted from Stewart, 1930, p. 33, 294)): *Panopea aldrovandi* Ménard de la Groye (= *Mya glycimeris* Born), living, eastern North Atlantic Ocean and Mediterranean Sea.

Panopea species

Plate 101, figure 1

Moderately large, ovate, height 70 percent of length, slightly inequilateral, strongly convex. Anterior end slightly gaping; posterior end more widely gaping. Anterior dorsal-lateral margin broadly rounded; posterior dorsal margin concave. Concentric sculpture irregular, relatively weak. Interior inaccessible.

Length 107 mm, height 75 mm, convexity (both valves) 30 mm (figured articulated internal mold).

Nine internal molds of *Panopea* were recovered from the lower member of the Alhajuela formation. They range in length from 24 to 107 mm. They may represent a new species characterized by a high ratio of height to length.

P. globosa (Dall, 1890–1903, pt. 4, p. 831, 1898; p. 560, pl. 40, fig. 1, 1902), a large eastern Pacific species (length 165 mm, height 124 mm), has a comparable ratio of height to length. It is, however, asymmetrically ovate. The anterior half of the shell is higher and more convex than the posterior half. Matching valves of the type, the only specimens now known, were collected on the beach at San Felipe, near the head of the Gulf of California.

Occurrence: Lower member of Alhajuela formation (early Miocene), localities 79, 82a.

Panopea parawhitfieldi (Gardner)

Plate 119, figures 20, 21

Panope parawhitfieldi Gardner, U.S. Geol. Survey Prof. Paper 142–E, p. 237, pl. 36, figs. 11, 12, 1928 (Miocene, Florida).

Moderately large, elongate-ovate, height 53 to 57 percent of length, moderately inequilateral, strongly convex. Anterior end moderately gaping; posterior end more widely gaping. Anterior dorsal-lateral margin broadly rounded; posterior dorsal margin concave. Concentric sculpture in umbonal area uniform, of closely spaced wide bands; elsewhere irregular, moderately strong. Interior inaccessible.

Length (incomplete) 120 mm (estimated restored length 140 mm), height 74 mm, convexity (both valves) 58.5 mm (figured right valve of articulated specimen). Length 88.5 mm, height 47 mm, convexity (both valves) 32.5 mm (type).

Type (articulated specimen): USNM 135913.

Type locality: Oak Grove, Yellow River, Okaloosa County, Fla., Oak Grove sand member of Shoal River formation.

An immature articulated internal mold from the upper member of the Alhajuela formation, an articulated shell of moderate size (both ends missing) from the lower part of the Gatun formation, a right valve of moderate size, and the illustrated large articulated shell, both from the middle part of the Gatun formation, are identified as *Panopea parawhitfieldi*. They are distinguished by their elongate outline and uniform strong sculpture in the umbonal area.

Mansfield (1938, p. 107, fig. 19) identified as *P.* cf. *P. parawhitfieldi* a small elongate, slightly inequilateral articulated shell (length 42.8 mm, height 24.6 mm) from limestone of Oligocene age in Washington County, Fla. It is too immature for satisfactory identification.

Occurrence: Upper member of Alhajuela formation (early Miocene), locality 89. Lower and middle parts of Gatun formation (middle Miocene). Lower part, locality 138c. Middle part, eastern area, locality 159d; western area, locality 160. Oak Grove sand member of Shoal River formation (middle Miocene), Florida.

Family PHOLADIDAE

Subfamily MARTESIINAE

Genus Martesia Sowerby

Sowerby, The genera of Recent and fossil shells, pt. 23, *Pholas*, p. 2, 1824 (cited as of Leach).

Type (monotype): *Pholas clavata* Lamarck (= *Pholas striata* Linné), living, practically worldwide in tropical seas.

Martesia sanctipauli Maury

Plate 120, figure 12

Martesia Sancti-Pauli Maury, Bull. Am. Paleontology, v. 5, no. 29, p. 234, pl. 39, fig. 23, 1917 (Miocene, Dominican Republic).

Martesia sanctipauli Maury, Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 73, p. 428, 1922 (Miocene, Dominican Republic).

?*Martesia* sp., Toula, K. k. Geol. Reichsanstalt Jahrb., v. 58, p. 734, 1909 (Miocene, Canal Zone).

Very small, asymmetrically ovate. Mesoplax elongate, narrow. Other accessory plates unknown. Umbonal reflection forming deep funnel-shaped pit. Umbonal-ventral sulcus narrow, deep. Anterior part of shell sculptured with narrow, closely spaced denticulate concentric threadlets; posterior part sculptured with low, slightly wider, smooth concentric threadlets.

Length 7.5 mm, height 6 mm, convexity about 3.5 mm (figured right valve). Length 8 mm, height 5 mm, convexity 3 mm (type).

Type (left valve): Paleontological Research Inst.

Type locality: Bluff 3, Cercado de Mao, Dominican Republic (same as USGS 8525), Cercado formation.

This small *Martesia* is represented in the Gatun formation by two right valves, one of which is incomplete, and about a dozen corroded specimens preserved in carbonized wood. If they are immature, as suggested by the presence of only the mesoplax, it is remarkable that the only valves so far known are of about the same size, whether they were found in the Dominican Republic or Panamá.

Occurrence: Lower and middle parts of Gatun formation (middle Miocene). Lower part, locality 138c. Middle part, western area, localities 160, 161c. Cercado formation (middle Miocene), Dominican Republic.

Family TEREDINIDAE

Unidentifiable tubes of wood-boring teredinids

Seven lots of tubes, more or less encased in wood, mostly carbonized were collected from the Culebra, La Boca, and Gatun formations. Those from the Culebra at locality 110, in the transition zone between the Culebra and Cucaracha formations (p. 35 of P 306–A) are exceptionally large (diameter as much as 20.5 mm), of a size comparable with many lots of *Kuphus*, listed under the next heading.

Toula's *Teredo* sp. (1909, p. 734) and *T. dendrolestes* (Brown and Pilsbry, 1911, p. 372, pl. 22, fig. 11 (not pl. 1, fig. 10), text-fig. 3), based on tubes and valve fragments from the Gatun, are regarded as *nomina dubia*.

Occurrence: Culebra formation (early Miocene), localities 105, 106, 110. La Boca formation (early Miocene), Gaillard Cut area, locality 101i. Middle part of Gatun formation (middle Miocene), eastern area, localities 153, 159b.

Subfamily KUPHINAE

Genus Kuphus Guettard

Guettard, Mémoires sur différentes parties des sciences et arts, v. 3, p. 139, 1770.

Type (logotype, Gray, Zool. Soc. London Proc., pt. 15, p. 188, 1847, spelled *Cuphus*, *Kuphus* and *Kyphus*): *Serpula polythalamia* Linné, Systema naturae, 12th ed., p. 1266, 1767, living, western Pacific and Indian Oceans.

Kuphus "incrassatus Gabb"

Plate 93, figure 5

Kuphus incrassatus Gabb, Am. Philos. Soc. Trans., new ser., v. 15, p. 246, 1873 (Miocene, Dominican Republic). Gabb, Acad. Nat. Sci. Philadelphia Jour., 2d ser., v. 8, p. 342, pl. 44, figs. 12a–e, 1881 (Miocene, Costa Rica, Dominican Republic). Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 64, p. 503 (list), 1913 (Miocene, Canal Zone). Mansfield, Jour. Paleontology, v. 14, no. 3, p. 201, pl. 27, fig. 35, 1940 (Oligocene, Alabama, Mississippi, Florida). Gardner, Geol. Soc. America Mem. 11, p. 140, 1945 (Oligocene, northeastern México). Toulmin, Gulf Coast Assoc. Geol. Socs., 12th Ann. Meeting, New Orleans, Guide Book, Little Stave Creek-Salt Mountain limestone, Jackson, Alabama, p. 26, pl. 1, fig. 1, 1962 (Oligocene, Alabama). Vokes, Tulane Studies Geol. Paleontology, v. 10, no. 1, p. 41, pl. 1, figs. 3–8, 1972 (Miocene, Florida, other American Oligocene and Miocene localities).

"*Kuphus*" aff. *incrassatus* Gabb, Rutsch, *in* Stainforth, Am. Assoc. Petroleum Geologists Bull., v. 32, no. 7, p. 1311 (list), 1948 (Oligocene or Miocene, Trinidad).

Teredo incrassata (Gabb), Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 4, p. 813 (list), 1898 (Miocene, Dominican Republic and other localities). Maury, Bull Am. Paleontology, v. 5, no. 29, p. 235, pl. 39, fig. 24, 1917 (Miocene, Dominican Republic). Maury, Sci. Survey Porto Rico and Virgin Islands, v. 3, no. 1, p. 45, 1920 (Oligocene and Miocene, Puerto Rico). Hubbard, Sci. Survey Porto Rico and Virgin Islands, v. 3, no. 2, p. 128, 1920 (Oligocene and Miocene, Puerto Rico).

Teredo? *incrassata* (Gabb), Mansfield, Florida Geol. Survey, Bull. 15, p. 282, pl. 21, fig. 4, 1937 (Oligocene, Florida). Mansfield, Washington Acad. Sci. Jour., v. 28, no. 3, p. 107, fig. 15, 1938 (Oligocene, Florida).

Teredo (*Kuphus*) *incrassatus* (Gabb), Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 73, p. 428, 1922 (Miocene, Dominican Republic).

Teredo fistula Lea?, Guppy, Geol. Soc. London Quart. Jour., v. 32, p. 529, 1876 (Miocene, Dominican Republic, not present Haiti).

Teredo circula Aldrich, Alabama Geol. Survey Bull. 1, p. 36, 1886 (Oligocene, Alabama, Mississippi).

Serpulorbis herculea Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 2, p. 303, 1892 (Oligocene, Florida).

Teredo sp. Cooke, Carnegie Inst. Washington Pub. 291, p. 146, 1919 (Oligocene and Miocene, Cuba).

Teredo (*Kuphus*) aff. *polythalamia* (Linné), Cox, Palaeontology of Zanzibar Protectorate, p. 62, pl. 8, fig. 1, 1927 (Eocene to Miocene, extensive distribution, including American Oligocene and Miocene localities).

Teredo sp., Ferreira and Rodrigues da Cunha, Mus. Paraense Emilio Goeldi Bol., new ser., Geologia, no. 8, p. 46, pl. 4, figs. 3a, 3b, 1959 (Miocene, Brasil).

Tubes thick, composed of calcite, posterior end narrower than anterior, almost invariably straight or almost straight. Divided posteriorly into two tubes for incurrent and excurrent siphons.

Length 62 mm, diameter of anterior end 13.4 mm, diameter of posterior end 6.5 mm (figured tube from Culebra formation).

Type lot: Acad. Nat. Sci. Philadelphia 2875.

Type locality: Valley of Río Yaque del Norte, east of Guayubín, Provincia de Monte Cristo, Dominican Republic (Gabb, 1873, p. 246).

Gabb realized he was dealing with *Kuphus*. In his original description, he mentioned the two posterior tubes, and in his 1881a publication, he illustrated cross sections of the two tubes, one for a specimen from the Dominican Republic and one for a specimen from Costa Rica.

About 50 specimens, all short tubes, are in collections from the shallow-water facies of the Caimito formation, the Culebra and La Boca formations, the Emperador limestone member of the La Boca, and the Gatun formation. The tubes are most widespread in the La Boca and taper off in the Gatun. Two specimens from the Culebra (localities 113a and 113b) and one from the La Boca (locality 115a) show the two posterior tubes in cross section.

Cox was dealing with Eocene tubes from Pakistan and Miocene tubes from East Africa. He also took into consideration tubes from Iran, southern France, and the East Indies. In Iran, he found them to be especially abundant in the Oligocene and early Miocene, just as in Latin America. Inasmuch as tubes from different areas and different ages have no diagnostic features, he decided to designate all of them as *Teredo* (*Kuphus*) aff. *polythalamia* (Linné). *Kuphus*, however, is not a subgenus of *Teredo*, it is in a different subfamily. As shown by Turner (1966, p. 20–23, fig. 6B), it is anatomically very different from *Teredo*. Fossil valves of *Kuphus* have never been found.

Though much is to be said in favor of *Kuphus* aff. *K. polythalamia* as an objective designation for all these tubes, for historical reasons, *Kuphus incrassatus*, but in the form *K.* "*incrassatus* Gabb," is retained for the American tubes. Despite its former extensive distribution, *Kuphus* is now living only in the western Pacific and Indian Oceans.

My colleague Druid Wilson found the tubes on which Dall based *Serpulorbis herculea*. They were collected at Jarves Spring, Hernando County, Fla., and evidently are from the Suwannee limestone. They have not been recorded since they were named by Dall.

Occurrence: Shallow-water facies of Caimito formation (late Oligocene), localities 56, 57a. Culebra formation (early Miocene), localities 112a, 113a, 113b. La Boca formation (early Miocene), Gaillard Cut area, localities 99d, 99g, 99h, 100a, 101h, 115a, 119, 119a, 120; Las Cruces area, locality 94. Emperador limestone member of La Boca formation (early Miocene), locality 118. Gatun formation (middle Miocene), middle part, eastern area, locality 153a; western area, localities 160, 161, 170. As outlined by Vokes, with some additions: formations of late Oligocene age, Puerto Rico, Jamaica, Cuba, Tampico area, México, northeastern México, Mississippi, Alabama, Florida, Georgia. Formation of early Miocene age, Brasil, Vieques, Puerto Rico, Anguilla, Jamaica, Cuba, Costa Rica, Guatemala, Florida. Formations of middle Miocene age, Dominican Republic, Jamaica, Trinidad.

Family PHOLADOMYIDAE

Genus Pholadomya Sowerby

Sowerby, The genera of Recent and fossil shells, pt. 19, 1823.
Type (logotype, Gray, Zool. Soc. London Proc., pt. 15, p. 194, 1847): *Pholadomya candida* Sowerby, living, southeastern West Indies.

Though the genus *Pholadomya* is rare in the Neogene of the Tertiary Caribbean province, it is represented in three of the Miocene formations under study: Culebra, Alhajuela, and Gatun. So far, it has been found in the Neogene of Aruba, Panamá, Colombia, Venezuela, Trinidad, and Perú. Dall and Ochsner (1928, p. 124, pl. 3, fig. 7, pl. 4, fig. 3) described *P. darwini* from the Pliocene of Indefatigable Island (Isla Santa Cruz) in the Galápagos. The genus may still be living in the eastern Pacific Ocean.

Pholadomya cf. P. walli Maury

Plate 98, figure 13

Of medium size, elongate-ovate, very inequilateral strongly convex. Posterior end gaping. Umbo very wide, high. Radial sculpture of narrow, closely spaced riblets. Concentric sculpture of wider bands, suppressed in interriblets. The two sets of sculpture narrowly cancellate. Concentric sculpture weak or absent in narrow posterior dorsal area. Interior inaccessible.

Length (almost complete) 77.2 mm (estimated restored length 81 mm), height 64 mm, convexity (both valves) 45 mm (figured right valve of articulated internal mold).

The single specimen, recovered from the Culebra formation, appears to be undeformed. The sculpture is more narrowly reticulate than that of *Pholadomya walli* (Maury, 1925a, p. 180, pl. 31, figs. 8, 11), a middle Miocene species from Trinidad.

Occurrence: Culebra formation (early Miocene), locality 111.

Pholadomya falconensis F. and H. Hodson

Plate 107, figure 1; plate 120, figure 21

Pholadomya falconensis F. and H. Hodson, *in* Hodson, Hodson, and Harris, Bull. Am. Paleontology, v. 13, no. 49, p. 44, pl. 26, fig. 6, pl. 27, figs. 1, 2, 1927 (Miocene, Venezuela).
Pholadomya sp., Olsson, Neogene mollusks from northwestern Ecuador, p. 72 (in discussion), pl. 5, fig. 2, Paleontological Research Inst., 1964 (Miocene, Canal Zone).

Reaching large size in upper member of Alhajuela formation, considerably smaller in Gatun formation. Trigonal-ovate, strongly inequilateral, strongly convex. Posterior end narrowly gaping. Umbo of moderate width and height. Radial riblets wide, relatively widely spaced. Concentric bands relatively wide, suppressed in interriblets. Interior inaccessible.

Length 88.5 mm, height 87.3 mm, convexity (both valves) 59.7 mm (figured left valve of articulated internal mold from upper member of Alhajuela formation). Length 81 mm, height 77.5 mm, convexity (both valves) 54.5 mm (figured right valve of articulated internal mold from Gatun formation). Length 100 mm, height 83 mm, convexity (both valves) 54 mm (type quoted from Hodson and Hodson.)

Type (articulated specimen): Paleontological Research Inst. 21993.

Type locality: Between La Vela and Taratara, Falcón, Venezuela, presumably La Vela formation (late Miocene).

Though *Pholadomya falconensis* occurs in the upper member of the Alhajuela formation and in the Gatun formation, it reaches a larger size in the Alhajuela (length as great as 113 mm) than in the Gatun, just as *Flabellipecten gatunensis* (p. 584) reaches a larger size in that formation. One of the large specimens among the three articulated internal molds from the Alhajuela is a lump of sandstone that shows a little sculpture in the umbonal part of the right valve. The specimen illustrated from the Alhajuela (pl. 107, fig. 1), which shows the sculpture to good advantage, is relatively small.

Olsson described and illustrated an anterior fragment of this species he found in a spoils dump from the Gatun Third Locks excavation. In 1911, however, MacDonald (1919) collected five articulated internal molds near the spillway of Gatun Dam site, all of which retain more or less of the thin shell. Some are distorted, but others, like that illustrated on plate 120, figure 21, are undeformed, except for minor pinching of the umbo.

Occurrence: Upper member of Alhajuela formation (early Miocene), localities 85 (identification doubtful), 90a, 91. Middle part of Gatun formation (middle Miocene), western area, locality 160. Presumably La Vela formation (late Miocene), Falcón, Venezuela.

Family PANDORIDAE

Genus Pandora Bruguiere

Bruguière, Encyclopédie methodique, Vers testacés, v. 2, pl. 250, figs. 1a–c, 1797, genus without named species.

Type (subsequent monotype, Lamarck, Soc. Hist. Nat. Paris Mém., p. 88, 1799): *Tellina inaequivalvis* Linné [*Solen inaequivalvis* Linné], living, eastern North Atlantic Ocean, England to Morocco, Mediterranean Sea.

Subgenus Pandorella Conrad

Conrad, Acad. Nat. Sci. Philadelphia Proc. for 1862, p. 572, 1863.

Type (monotype): *P[andorella]* (*Pandora*) *arenosa* Conrad, Miocene to living; living, North Carolina to Texas and Yucatan.

Pandora (Pandorella) inconspicua Gabb

Plate 120, figure 4

Pandora inconspicua Gabb, Am. Philos. Soc. Trans., new ser., v. 15, p. 248, 1873 (Miocene, Dominican Republic). Maury, Bull. Am. Paleontology, v. 5, no. 29, p. 195, pl. 26 figs. 19 19a, 1917 (Miocene Dominican Republic). Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 73, p. 414, pl. 38, figs. 8, 9, 1922 (Miocene, Dominican Republic).

Very small, elongate, very inequilateral, left valve slightly convex. Prismatic layer missing; nacreous layer more or less exfoliated. Fairly strong radial riblet close to posterior dorsal margin on left valve. Right valve unknown. Interior defective.

Length 8 mm, height 3.5 mm, convexity about 1.5 mm (figured left valve). Length 7 mm, height 3.3 mm (lectotype, quoted from Pilsbry).

Type material: Lectotype, designated by Pilsbry, left valve, Acad. Nat. Sci. Philadelphia 2676.

Type locality: Dominican Republic, Miocene, presumably Cercado formation.

Two localities in the middle part of the Gatun formation yielded three left valves of this small *Pandora*. *P. dodona* (Dall, 1890–1903, pt. 6, p. 1518, pl. 57, fig. 25, 1903; Miocene, Florida) is a little larger and its dorsal radial riblet is somewhat weaker.

Occurrence: Middle part of Gatun formation (middle Miocene), eastern area, localities 147b, 159d. Cercado formation (middle Miocene), Dominican Republic.

Family THRACIIDAE

Genus Cyathodonta Conrad

Conrad, Acad. Nat. Sci. Philadelphia Proc., v. 4, p. 155, 1848 (1849).

Type (monotype): *C[yathodonta] undulata* [Conrad], living, southern part of Gulf of California to northern Perú.

Cyathodonta? dolicha Woodring, n. sp.

Plate 91, figure 22

Of medium size, elongate, moderately inequilateral, left valve slightly convex. Anterior dorsal margin slightly convex; posterior dorsal margin slightly concave. Anterior end broadly rounded; extreme posterior end missing. Posterior dorsal part of shell depressed. Umbo very low, very narrow. Sculpture of relatively narrow, closely spaced concentric ripples, subdued on depressed posterior dorsal part. Right valve unknown. Interior inaccessible.

Length (incomplete) 30 mm (estimated restored length 33 mm), height 18 mm, convexity about 5 mm (type).

Type (left valve): USNM 647801.

Type locality: 42d (USGS 18837, Barro Colorado Island, northern part of island, stream heading west of Miller Trail near Miller 17, about 100 m above mouth), upper part of Bohio formation.

The type, an internal mold of a left valve that retains some shell material, the sole specimen of *Cyathodonta*? *dolicha*, was recovered from a marine lens in the upper part of the Bohio formation on Barro Colorado Island. Though the posterior part of the shell is depressed, like that of *Cyathodonta*, this species is not a typical *Cyathodonta*. It is elongate and the ripples are relatively narrow.

Occurrence: Bohio formation (late Oligocene), locality 42d.

Cyathodonta? cf. C.? dolicha Woodring, n. sp.

Plate 121, figure 8

An articulated internal mold from the middle part of the Gatun formation at locality 139f and another immature mold collected at locality 159 have the outline of *Cyathodonta*? *dolicha*. The left valve is more convex than the right. The posterior end is obliquely subtruncated. The sculpture of narrow concentric ripples is not as strong as that of *C.*? *dolicha*.

Length 35.7 mm, height 23.3 mm, convexity (both valves) 14 mm (figured right valve of articulated internal mold).

Occurrence: Middle part of Gatun formation (middle Miocene), eastern area, localities 139f, 159.

Cyathodonta aff. C. gatunensis (Toula)

Three incomplete internal molds of valves of moderate size, from the La Boca formation, are sculptured with coarse concentric ripples. These fossils are regarded as immature valves of *Cyathodonta gatunensis* or as representatives of an earlier closely allied species.

Occurrence: La Boca formation (early Miocene), Gaillard Cut area, localities 114, 115, 115a.

Cyathodonta gatunensis (Toula)

Plate 121, figure 7

Thracia gatunensis Toula, K. k. Geol. Reichsanstalt Jahrb., v. 58, p. 757, text-fig. 15, 1909 (Miocene, Canal Zone).

Thracia (*Cyathodonta*) *gatunensis* Toula, Brown and Pilsbry, Acad. Nat. Sci. Philadelphia Proc., v. 64, p. 518, pl. 26, fig. 3, 1913 (Miocene, Canal Zone). Through lapsus recorded on p. 501 as *Thracia* (*Cyathodonta*) *isthmica* n. sp. in list of species from Gatun Dam spillway.

Moderately large, semielliptical, height 69 or 70 percent of length, moderately inequilateral, right valve slightly higher, and slightly more convex than left. Anterior dorsal margin very slightly convex; posterior dorsal margin slightly concave at umbo. Area adjoining posterior end depressed. Anterior end broadly rounded; posterior end more narrowly rounded, extreme posterior end missing. Umbo very low, very narrow. Sculpture of coarse concentric ripples, absent on posterior depressed area. Interior inaccessible.

Length (practically complete) 44.7 mm, height (practically complete) 30.5 mm, convexity (both valves) 14 mm (figured left valve of articulated internal mold from Gatun formation). Length 52 mm, height 36 mm (type, quoted from Toula).

Type: Paläontologisches Inst., Univ. Wien.

Type locality: Presumably Gatun Locks excavation.

Olsson (1922, p. 211, pl. 20, fig. 3; middle Miocene southeastern Costa Rica) claimed that the sculpture of *C. gatunensis* is concentric throughout, whereas that of his *C. tristani* is oblique on the posterior ventral area. Owing to defective ventral margins on Toula's illustration of the type and on the illustrated specimen from the Gatun, this matter cannot be resolved. Rutsch (1942, p. 126) raised the question whether the two forms are identical.

Dall described as two species *C. guadelupensis* (Dall, 1890–1903, pt. 6, p. 1527, pl. 53, fig. 6, 1903; length 39.8 mm) and *C. spenceri* (p. 1527, pl. 53, fig. 8; length 44.3 mm), two specimens J. W. W. Spencer brought back from Guadeloupe. Both are limestone articulated internal molds, and on both, the right valve is decidedly higher and decidedly more convex than the left. Though they differ in outline, they have much in common and are to be treated as one species, which is not similar to *C. gatunensis*. Spencer wrote about his 1897 visit to Guadeloupe (Spencer, 1901) but mentioned nothing about the specimens of *Cyathodonta*. They presumably were collected from the Miocene Grande-Terre limestone.

Rutsch (1942, p. 126, pl. 6, fig. 4) identified as *C. tristani* a fossil from the late Miocene Springvale formation of Trinidad. Two lots of six specimens of *Cyathodonta* from the Savaneta glauconitic sandstone member of the Springvale, deposited in the USNM by Dr. H. G. Kugler, include a large specimen in better condition than that illustrated by Rutsch. It is exceptionally large: length 74.5 mm, height 52 mm, convexity (both valves) 23 mm—the largest American species. Moreover, this undescribed species is characterized by a narrow shallow sulcus close to the anterior edge of the posterior depressed area.

Occurrence: Upper member of Alhajuela formation (early Miocene), locality 89. Middle part of Gatun formation (middle Miocene), eastern area, locality 159d. Toro limestone member of Chagres sandstone (late Miocene or early Pliocene), locality 195.

Family CUSPIDARIIDAE

Genus Cuspidaria Nardo

Nardo, Annali delle Scienze del Regno Lombardo-Veneto, v. 10, p. 50, 1840.

Type (orthotype): *Cuspidaria typus* Nardo (= *Tellina cuspidata* Olivi), living, eastern North Atlantic Ocean and Mediterranean Sea.

Cuspidaria cf. C. obesa Loven

Plate 120, figure 20

Very small, rostrum short. Main part of shell strongly convex. Sculpture of faint growth lines. Interior inaccessible.

Length 5.5 mm, height 3.5 mm, convexity about 1.5 mm (figured left valve).

A left valve, on which the shell is missing on about the anterior third, was found in the upper part of the Gatun formation. In general features it is similar to the living *Cuspidaria obesa* Lovén but has less distinct growth-line sculpture and generally is smaller.

C. obesa has a remarkable geographic and depth range: the Arctic Ocean to Barbados, and 20 to 1,290 fathoms. Dall and Simpson (1901, p. 497) recorded it from Mayaguez, Puerto Rico (30 fathoms) and Barbados (100 fathoms). The valve from the Gatun is comparable in size to the six valves from Mayaguez.

C. juanadiaza (Maury, 1920, p. 27, pl. 5, fig. 4, Oligocene, Puerto Rico) is the only species on record from the Tertiary Caribbean province. It is larger, elongate, and more strongly sculptured than the valve from the Gatun.

Occurrence: Upper part of the Gatun formation (middle Miocene), locality 177d.

Genus Cardiomya A. Adams

A. Adams, Annals and Mag. Nat. History, 3d ser., v. 13, p. 206, 1864.

Type (monotype): *Cardiomya Gouldiana* (Hinds) (*Neaera Gouldiana* Hinds), living, Japan.

Cardiomya species

Plate 91, figure 10

Relatively large, strongly rostrate. Main part of shell strongly convex. Rostrum long, narrow. Traces of fine radial riblets at anterior end of shell. Interior inaccessible.

Length 9.8 mm, height 4 mm, convexity about 1.5 mm (figured right valve).

A right valve from the moderately deep water facies of the Caimito formation on Barro Colorado Island is badly corroded; in fact, no shell remains on almost the entire main part of the valve. The affinities of this species are undetermined.

Occurrence: Caimito formation (late Oligocene), locality 54 m.

Cardiomya mansfieldi (Olsson and Harbison)

Plate 120, figure 2

Cuspidaria (*Cardiomya*) *mansfieldi* Olsson and Harbison, Acad. Nat. Sci. Philadelphia Mon. 8, p. 66, pl. 8, fig. 11, 1953 (Pliocene, Florida).

Cuspidaria (*Cardiomya*) *ornatissima* (d'Orbigny), Mansfield, Florida Geol. Survey Bull. 8, p. 75, pl. 12, fig. 8, 1932 (Miocene, Florida).

Small, most of rostrum missing. Sculpture of seven radial ribs, strongest and widely spaced on median part of shell; remainder progressively more closely spaced adanteriorly, and weak secondary riblet in anteriormost interribs.

Length 5.8 mm, height 4 mm, convexity about 2 mm (figured right valve).

The middle part of the Gatun formation yielded a small right valve that lacks most of the rostrum. In size and type of sculpture it is comparable with the type of *Cardiomya mansfieldi*.

It is by no means certain that *C. ornatissima vaughani* (Mansfield, 1932b, p. 75, pl. 12, figs. 5, 6; deposits of late Miocene age, Florida) is the same as *C. mansfieldi*.

Occurrence: Middle part of Gatun formation (middle Miocene), eastern area, locality 159d. Deposits of late Miocene age, western Florida. Caloosahatchee formation (Pliocene), Florida.

ADDITIONS TO FAMILIES COVERED IN P 306–E

The following two species were overlooked in the preparation of P 306–E.

Family MANZANELLIDAE

Genus Nucinella Wood

Wood, A monograph of the Crag Mollusca, pt. 2, p. 72, Palaeontographical Soc., 1851.

Type (logotype, Stoliczka, India Geol. Survey Mem., Palaeontologia Indica, Cretaceous fauna of southern India, v. 3, p. 334, 1871): *Pleurodon ovalis* Wood, cited by Wood as a synonym of the misidentified *Nucinella miliaris* (Deshayes), the sole species he assigned to *Nucinella*, Pliocene [Pleistocene], England.

Nucinella cf. N. woodii (Dall)

Plate 120, figure 15

Minute, obliquely ovate, inequilateral, convexity moderately strong. Posterior dorsal margin slightly auriculate. Posterior margin strongly arcuate above midpoint of height; anterior margin smoothly arcuate. Surface smooth and polished; a "resting stage" near ventral margin. As pointed out by Mr. Waller, the ligament insertion is visible on the posterior side of the umbos, thus confirming the generic identification.

Length 1.1 mm, height 1.6 mm, convexity (both valves) about 0.85 mm (figured articulated specimen).

Locality 147b yielded a minute articulated specimen of *Nucinella*, the first record, fossil or living, of the genus in the Caribbean region. That locality, in the middle part of the Gatun formation, is notable for the large number of very small or immature fossils.

Though it may be immature, this minute fossil is smaller and shorter than late Tertiary specimens from Florida: *N. woodii* (Dall, 1890–1903, pt. 4, p. 600, pl. 24, fig. 10, 1898; Pliocene Caloosahatchee formation; Mansfield, 1932b, p. 37, pl. 2, figs. 1, 3; late Miocene, Florida) and *N. gunteri* (Mansfield, 1932b, p. 37, pl. 2, figs. 4, 6; middle Miocene, Florida). Whether two taxa are represented by Mansfield's specimens is doubtful. The fossil from the Gatun is decidely smaller and shorter than *N. adamsi*

(Dall, 1890–1903, pt. 4, p. 601, in discussion, pl. 24, fig. 9, 1898), living off southern Florida.

Occurrence: Middle part of Gatun formation (middle Miocene), locality 147b.

Family MYTILIDAE

[p. 522 of P 306–E]

Genus Lithophaga Roding

Röding, Museum Boltenianum, p. 156, 1798.
Type (monotype): *Lithophaga mytuloides* Röding = *Mytilus lithophagus* Linné, cited as of Gmelin, in synonymy, living, eastern and western North Atlantic Ocean, eastern North Pacific Ocean.

Subgenus Lithophaga s.s.

Lithophaga (Lithophaga) nigra (d'Orbigny)

Plate 86, figure 6

Lithodomus niger d'Orbigny, Mollusques, in de la Sagra, Histoire physique, politique, et naturelle de l'île de Cuba, v. 2, p. 331, 1853; Atlas, pl. 28, figs. 10, 11, 1842 (living, Cuba and other West Indian islands).

Lithophaga nigra (d'Orbigny), Maury, Bull. Am. Paleontology, v. 5, no. 29, p. 194, 1917 (Miocene, Dominican Republic). Cooke, Carnegie Inst. Washington Pub. 291, p. 146, pl. 14, fig. 6, 1919 (Oligocene, Antigua). Maury, New York Acad. Sci., Scientific Survey of Porto Rico and Virgin Islands, v. 3, p. 24, 1920 (Oligocene, Puerto Rico). Hubbard, New York Acad. Sci., Scientific Survey of Porto Rico and Virgin Islands, v. 3, p. 103, 1920 (Oligocene, Puerto Rico).

?*Lithophaga nigra* (d'Orbigny), Dall, Wagner Free Inst. Sci. Trans., v. 3, pt. 4, p. 799, 1898 (Miocene, Florida). Mansfield, Florida Dept. Conservation, Geol. Bull. 15, p. 223, 1937 (Miocene, Florida).

Lithophaga (*Lithophaga*) *nigra* (d'Orbigny), Turner and Boss, Johnsonia, v. 4, no. 41, p. 96, pl. 65, 66, 75, figs. 2, 3, 1962 (living, Florida to northern Brasil).

Of medium size, elongate elliptical, umbo close to anterior end, dorsal margin slightly angulated. Growth lines exaggerated and ledgelike at irregular intervals on posterior part. Faint dorso-ventral fine ripples, except above a line extending from anterior dorsal margin near umbo obliquely across shell to ventral margin near posterior end, most distinct near middle ventral part. Interior inaccessible.

Length 39.3 mm, height 12.7 mm, convexity (both valves) 9.8 mm (figured specimen).

Type material: Three syntypes, British Museum (Natural History) 1854.10.4,606.

Type locality: Cuba, living.

Three articulated specimens from the Gatuncillo formation in Madden basin, for the most part probably the aragonite layer recrystallized to calcite, extend the age range of this living species back to late Eocene time. It is the first living species found so far in that formation and in other Eocene faunas of the Caribbean region. According to the catalogue of Palmer and Brann (1965–66), no living species is recognized in the late Eocene faunas of southern and eastern United States. The illustrated specimen is the only complete one of the three available. They are smaller than the largest living shells, which reach a length of 65.5 mm, as recorded by Turner and Boss (58.5 mm in USNM collections). The late Oligocene Antiguan specimen illustrated by Cooke has a length of 44.5 mm. The single incomplete small (length 17.5 mm) specimen from the Tampa limestone of Florida, identified by Dall and Mansfield as this species, is unidentifiable.

Occurrence: Gatuncillo formation (late Eocene), locality 11. Lares limestone (late Oligocene), Puerto Rico. Antigua formation (late Oligocene), Antigua. Cercado formation (middle Miocene), Dominican Republic. Living, southern Florida and Bahamas through West Indies to Esperito Santo, Brasil.

ADDITIONS TO GASTROPODS

Two exceptionally large species of gastropods, found in limestone of the Gatuncillo formation in Madden basin, are the only notable gastropods recovered since publication of P 306–E.

Family NERITIDAE

[p. 66 of P 306–A]

Velates perversus (Gmelin)

[p. 66 of P 306–A]

Plate 84 figure 3

The illustrated large specimen of *Velates perversus* was collected in 1974, in the valley of Río la Puente, by Miss Luz Jolly, a student of Mr. R. H. Stewart at Canal Zone Junior College. It was found in limestone in a roadcut on Route 81, a short distance south of the ford across Río la Puente.

Much of the shell is intact on the apical face, but the entire apertural face is missing.

Though this species had been collected previously at four localities near Río la Puente, the largest (locality 7) is about half as large as that now illustrated.

The designation *Velates perversus* subspecies? refers only to the silicified specimens from locality 38. They show the aperture, which is missing on others.

Maximum diameter 19 cm, minimum diameter 16.2 cm, height 9 cm (figured specimen). So far as known this is a size record for America.

Occurrence: Gatuncillo formation (late Eocene), locality 12a.

Family CYPRAEIDAE

[p. 193 of P 306–B]

Genus Megalocypraea Schilder

Schilder, Senckenbergiana, v. 9, no. 5, p. 199, 211, 1927.
Type (orthotype, p. 211): *Gisortia* (*Megalocypraea*) *ovumstruthionis* Schilder n. sp., p. 211, fig. 13, (2 figs.), Eocene, Bavaria).

The type of the type species is an internal mold that has a defective siphonal canal. So far as known, the only illustrations of it are Schilder's original outline drawings, which were reduced to half natural size in Wenz's compilation ((1941, p. 967, fig. 2804, (2 figs.)).

Schilder (1932, p. 126–127) recognized a dozen species and subspecies of *Megalocypraea*, ranging in age from late Late Cretaceous to middle Eocene and geographically from England, Belgium, France, and Bavaria to Baluchistan, Pakistan, and Perú.

Ovula tuberculosa Duclos (*in* Dictionnaire des Sciences Naturelles, 1825, v. 37, p. 132; Ypresian, northern France) would be a much better type species for *Megalocypraea*. The earleist illustrations of that species, very good illustrations, are on an unnumbered, unlabelled plate, between supplementary plates 29 and 31 in the part of volume 5 of the Zoological Journal that was issued in 1829. Readily available illustrations of a specimen from the Cuisian of the Paris basin were published by Cossmann and Pissarro (1910–13, pl. 32, figs. 161–1, 2 figs.). They were reproduced by Clark and Vokes (1936). As *Cypraea tuberculosa* (*Coombii*) J. de C. Sowerby, *Megalocypraea tuberculosa* occurs in the Bracklesham beds (middle Eocene) of England (Edwards, 1854, p. 131, pl. 16, fig. 2, pl. 17, fig. 5).

Megalocypraea aff. M. clarki (Ingram)

Plate 85, figure 3; plate 86, figure 3

Very large in height and in both lateral and dorsoventral diameter, ovate. Indistinct angulation on upper part of dorsal surface. Mold shows apex of 3½ rapidly enlarging whorls. Aperture, filled with limestone matrix, moderately narrow, dorsal part bent to left in apertural view. Outer lip flattened, rising above apex. Vague traces of teeth on mold, on part of outer lip. Inner lip gently rounded. Siphonal canal defective.

Height 16.8 cm, lateral diameter 13 cm, dorsal-ventral diameter 12.5 cm (figured internal mold).

The illustrated internal mold was found in 1974 by Mr. R. H. Stewart in a limestone quarry 1.6 km S.59°W. from Río Indio Hydrographic Station, in Madden basin, Panama. (The Station is plotted as locality 1 on plate 1 of P 306–A.) A low, narrow, spirally elongate ridge on the dorsal surface close to the outer lip and below the indistinct angulation was removed, as it was thought to be matrix. It, however, doubtless was a "tubercle." Whether a shallow axial depression on the ventral half of the dorsal surface, alined with the siphonal canal, is a natural feature is problematical.

This species is closely allied to *M. clarki* (Ingram, 1940, p. 376, fig. 1; *Gisortia* n. sp., Clark and Vokes, 1936, p. 877, pl. 2, figs. 1, 3). Despite the considerable difference in size—length 16.8 cm compared with 12.1 cm—it may be that species. Ingram and Clark and Vokes properly compared *M. clarki* with *M. tuberculosa*.

M. clarki was based on one specimen from the Llajas formation, of middle Eocene age, in the hills north of Simi Valley, Ventura County, Calif., the formation that yielded the type species of *Exputens* (p. 527 of P 306–E).

The specimen from Madden basin establishes a size record for the genus in America. There is, however, little competition: only *M. clarki* and *M. thomasi* (Olsson, 1930, p. 64, pl. 8, figs. 1, 2, 7; early Eocene, Perú); length 11.8 cm.

Occurrence: Gatuncillo formation (late Eocene), locality 5a.

CEPHALOPODS

Family NAUTILIDAE

Subfamily ATURINAE

Genus Aturia Brown

Bronn, Lethaea geonostica, v. 2, p. 1122, 1838.
Type (logotype, Herrmannsen, Indicis generum malacozoorum primordia, v. 1, p. 90, 1847, and virtual tautotype): *Aturia aturi* (Basterot) (*Nautilus aturi* Basterot), Miocene, Aquitaine.

Aturia species

Plate 91, figures 16, 17

A small, presumably immature, *Aturia* was found in a marine lens in the upper part of the Bohio formation of Barro Colorado Island. The umbilicus is very small and the siphuncle is dorsal in position.

This species suggests the unnamed species from the Lares limestone of Puerto Rico (late Oligocene) recorded by Miller (1947, p. 112, pl. 87, figs. 1, 2).

Greatest preserved diameter 37 mm, greatest thickness 14.3 mm (figured specimen).

Occurrence: Bohio formation (late Oligocene), locality 42d.

Aturia curvilineata Miller and Thompson?

Plate 120, figures 5, 6

An incomplete specimen of moderate size, collected by David and Robert Stewart, is the only *Aturia* in the many collections from the Gatun formation. It is doubtfully identified as *A. curvilineata* (Miller and Thompson, 1937, p. 69, pl. 9, figs. 1–4, pl. 10, figs. 1, 2), which was based on specimens from the middle Miocene Cantaure formation of Venezuela. The type lot of *A. curvilineata* has been synonymized under *A. cubaensis*, a Cuban species of uncertain age, presumably Oligocene or Miocene (Jung, 1966, p. 489).

Greatest preserved diameter 61 mm, greatest thickness 18.4 mm (figured specimen).

Occurrence: Middle part of Gatun formation (middle Miocene), eastern area, locality 139a.

CONSOLIDATED AND REVISED LIST OF LOCALITIES AT WHICH FOSSILS WERE COLLECTED

No. used in this report		USGS Cenozoic No.	Field No.	Description of locality, remarks, corrections. [Only new entries are fully described. See P 306A–D for original locality descriptions]
Consecutive order	Stratigraphic order			
				GATUNCILLO FORMATION (MIDDLE AND LATE EOCENE)
1	1	--------	131	No change. Entered in P 306–A.
1a	1a	--------	131a	Do.
2	2	--------	132	Do.
3	3	8400	--------	Do.
4	4	--------	150	Do.
5	5	--------	118	Do.
5a	5a	25711	--------	Limestone quarry 1.6 km S.59°W. of Río Indio Hydrographic Station, Madden basin, Panamá. Limestone. R. H. Stewart, 1974. New entry.
6	6	17433	114	No change. See P 306–A.
7	7	17432	115	Do.
8	8	--------	116	Do.
9	9	17161	113	Do.
10	10	--------	108	Cazalda Larga instead of Casa Larga. Entered in P 306–A.
11	11	16889	15	Do.
12	12	17162	107	Do.
12a	12a	25712	--------	Roadcut on Route 81, 560 m southwest of ford across Río La Puente and 2 km northeast of north end of abandoned Madden Airstrip, Madden basin, Panamá. Limestone. Miss Luz Jolly, 1974. New entry.
13	13	--------	106	Cazalda Larga instead of Casa Larga. Entered in P 306–A.
14	14	--------	105	Do.
15	15	--------	129	Do.
16	16	17434	128	Do.
17	17	--------	147	No change. Entered in P 306–A.
18	18	--------	146	Do.
19	19	--------	145	Do.
20	20	--------	19	Do.
21	21	--------	20	Do.
22	22	--------	124	Do.
23	23	--------	125	Do.
23a	23a	--------	--------	Do.
23b	23b	24553	--------	No change. Entered in P 306–D.
24	24	--------	21	No change. Entered in P 306–A.
25	25	--------	139	Do.
26	26	--------	23	Do.
27	27	16931	22	Do.
27a	27a	--------	22a	Do.
28	28	--------	140	Do.
29	29	--------	--------	Do.
30	30	--------	--------	Do.
31	31	--------	--------	Do.
32	32	17163	136	Do.
33	33	--------	137	Do.
34	34	17165	--------	Do.
35	35	17700	135	Do.
36	36	--------	134	Do.
37	37	--------	138a	Do.
37a	37a	23648	--------	No change. Entered in P 306–D.
38	38	17166	119	No change. Entered in P 306–A.
39	------	--------	--------	*See under* Bohio formation.

No. used in this report		USGS Cenozoic No.	Field No.	Description of locality, remarks, corrections. [Only new entries are fully described. See P 306A–D for original locality descriptions]
Consecutive order	Stratigraphic order			
				MARINE ROCKS OF LATE EOCENE AGE (ORIGINALLY ASSIGNED TO LATE EOCENE OR EARLY OLIGOCENE)
40	40	--------	--------	No change. Entered in P 306–A.
40a	40a	2683	18	Do.
40b	40b	2685	19	Do.
40c	40c	2687	26	Do.
40d	40d	6028a	--------	Do.
40e	40e	6028b	--------	Do.
41	41	17716	148	Do.
41a	41a	18838	208	Do.
41b	41b	18839	209	Do.
42	42	17692	149	Do.
42a	42a	17693	149a	Do.
42b	42b	--------	149b	Do.
42c	42c	17695	149c	Do.
42d to g	-------	--------	--------	*See under* Bohio formation.
42h	42h	--------	215	No change. Entered in P 306–A.
42i	-------	--------	--------	*See under* Bohio formation.
43 to 45	-------	--------	--------	*See under* marine facies of Panamá formation.
				BOHIO FORMATION (LATE OLIGOCENE)
	39	--------	127	No change. Entered in P 306–A.
	42d	18837	207	Do.
	42e	18835	205	Do.
	42f	18836	206	Do.
	42g	18832	203	Do.
	42i	18845	215a	Locality 42h instead of 54b. Entered in P 306–A.
				CAIMITO FORMATION, GATUN LAKE AREA (LATE OLIGOCENE), SHALLOW-WATER FACIES
46	46	--------	41	No change. Entered in P 306–A.
47	47	--------	42	Do.
48	48	--------	43	Do.
				CAIMITO FORMATION, GATUN LAKE AREA (LATE OLIGOCENE), SHALLOW-WATER FACIES—Continued
49	49	6021	--------	Do.
50	50	--------	44	Do.
51	51	--------	45	Do.
52	52	6024b	--------	Do.
52a	52a	5908	--------	Do.
53 to 54a	-------	--------	--------	*See under* Caimito formation, moderately deep water facies.
54b and c	-------	--------	--------	Never used.
54d	-------	--------	--------	*See under* Caimito formation, moderately deep water facies.
54e	54e	--------	202a	No change. Entered in P 306–A.
54f	54f	--------	201	Do.
54g and h	-------	--------	--------	*See under* Caimito formation, moderately deep water facies.
54i	54i	--------	211	No change. Entered in P 306–A.
54j to 55a	-------	--------	--------	*See under* Caimito formation, moderately deep water facies.
55b	55b	18847	216a	No change. Entered in P 306–A.
56	56	6025	--------	Do.
56a	56a	--------	55	Do.
57	57	6026	--------	Do.
57a	57a	5901	--------	Do.
58	58	--------	54	Do.
59 to 61	-------	--------	--------	*See under* Caraba formation.
				CAIMITO FORMATION, GATUN LAKE AREA (LATE OLIGOCENE), MODERATELY DEEP WATER FACIES
	53	--------	53	No change. Entered in P 306–A.
	54	--------	46	Do.
	54a	--------	214	Do.

No. used in this report		USGS Cenozoic No.	Field No.	Description of locality, remarks, corrections. [Only new entries are fully described. See P 306A–D for original locality descriptions]
Consecutive order	Stratigraphic order			
				CAIMITO, FORMATION, GATUN LAKE AREA (LATE OLIGOCENE), MODERATELY DEEP WATER FACIES—Continued
	54d	--------	202	Do.
	54g	18840	210	Do.
	54h	18841	210a	Do.
	54j	18833	204	Do.
	54k	18834	204a	Do.
	54l	18842	212	Do.
	54m	18843	213	Do.
	54n	18844	213a	Do.
	55	--------	--------	Do.
	55a	18846	216	Do.
				QUEBRANCHA LIMESTONE MEMBER OF CAIMITO FORMATION, QUEBRANCHA SYNCLINE, PANAMÁ (LATE OLIGOCENE)
62	62	16939	11	No change. Entered in P 306–A.
62a	62a	--------	11a	Do.
				CAIMITO FORMATION, MADDEN BASIN, PANAMÁ (LATE OLIGOCENE)
63	63	--------	29	No change. Entered in P 306–A.
64	64	--------	30	Do.
65 and 66	--------	--------	--------	*See under* lower member of Alhajuela formation.
67	67	--------	121	Cazalda Larga instead of Casa Larga. Entered in P 306–A.
68	68	--------	120	Do.
69	69	--------	123	Do.
70	70	--------	130	Do.
				CAIMITO FORMATION, MADDEN BASIN, PANAMA (LATE OLIGOCENE)—Continued
71 to 73	--------	--------	--------	*See under* Emperador limestone member of La Boca formation, Madden basin.
74 and 74a	--------	--------	--------	*See under* lower member of Alhajuela formation.
75	--------	--------	--------	*See under* La Boca formation, Madden basin.
76 to 84a	--------	--------	--------	*See under* lower member of Alhajuela formation.
85 to 92	--------	--------	--------	*See under* upper member of Alhajuela formation.
93	--------	--------	126	Delete. Erroneous field identification.
94 and 94a	--------	--------	--------	*See under* La Boca formation, Las Cruces area.
95 to 96a	--------	--------	--------	*See under* marine facies of Panamá formation.
				CARABA FORMATION (LATE OLIGOCENE)
	59	--------	110	No change. Originally assigned to Caimito formation. Entered in P 306–A.
	60	17685	111	Do.
	61	--------	112	Do.
97	97	--------	18	Do.
				MARINE FACIES OF PANAMÁ FORMATION (LATE OLIGOCENE)
	43	--------	39	No change. Originally asigned to Bohio formation. Entered in P 306–A.

No. used in this report		USGS Cenozoic No.	Field No.	Description of locality, remarks, corrections. [Only new entries are fully described. See P 306A–D for original locality descriptions]
Consecutive order	Stratigraphic order			
				MARINE FACIES OF PANAMÁ FORMATION (LATE OLIGOCENE)—Continued
	43a	--------	RPP19	No change. Entered in P 306–B.
	44	17435	109	No change. Entered in P 306–A.
	45	18375	38	Do.
	95	--------	37	No change. Originally assigned to Caimito formation. Entered in P 306–A.
	96	--------	104	Do.
	96a	--------	--------	Do.
				CULEBRA FORMATION (EARLY MIOCENE)
98 to 102a	--------	--------	--------	*See under* La Boca formation, Gaillard Cut area.
103	103	6012b	--------	Near Canal station 1884. Entered in P 306–A.
103a	103a	25917	--------	Same locality, loose on slope. W. P. Woodring and J. R. Schultz, 1947. New entry.
104	104	16933	31	Canal station 1892. Entered in P 306–A.
104a	104a	6976	--------	Presumably near Canal station 1892. Entered in P 306–A.
104b	104b	5863	--------	Near Canal station 1892. Entered in P 306–A.
105	105	6517	--------	Between Canal stations 1913 and 1923. Entered in P 306–A.
106	106	6012c	--------	Near Canal station 1922. Entered in P 306–A.
107	107	6012d	--------	Near Canal station 1930. Entered in P 306–A.
				CULEBRA FORMATION (EARLY MIOCENE)—Continued
107a	107a	25186	--------	East side of Culebra Reach, about 350 feet (107 m) east of east prism line at Canal station 1922 plus 40 feet (12 m). R. H. Stewart and J. L. Stewart, 1972. New entry.
107b	107b	25780	--------	East side of Culebra Reach, oyster reef in upper part of Culebra formation exposed in slide area at Canal station 1926 plus 50 feet (15 m). R. H. Stewart and W. P. Woodring, 1976. New entry.
108	108	--------	--------	Canal station 1922. Entered in P 306–A.
108a	108a	16951	1a	Same locality. Entered in P 306–A.
108b	108b	4897	--------	Presumably near Canal station 1922. Entered in P 306–A.
108c	108c	5859	--------	Canal station 1922. Entered in P 306–A.
109	109	6013	--------	Canal station 1924. Entered in P 306–A.
110	110	16886	5	Canal station 1916. Entered in P 306–A.
110a	110a	6508	--------	Canal station 1917. Entered in P 306–A.
111	111	--------	--------	Canal station 1916. Entered in P 306–A.
111a	111a	16887	25	Canal station 1917. Entered in P 306–A.
111b	111b	16888	25a	Canal station 1916. Entered in P 306–A.

No. used in this report		USGS Cenozoic No.	Field No.	Description of locality, remarks, corrections. [Only new entries are fully described. See P 306A–D for original locality descriptions]
Consecutive order	Stratigraphic order			
				CULEBRA FORMATION (EARLY MIOCENE)—Continued
112	112	16910	2	Canal station 1922. Entered in P 306–A.
112a	112a	16927	3	Same locality. Entered in P 306–A.
112b	112b	24502	--------	No change. Entered in P 306–D.
112c	112c	24505	--------	About Canal station 1892. Entered in P 306–D.
113 to 116a	-------	--------	--------	*See under* La Boca formation, Gaillard Cut area.
117 to 118b	-------	--------	--------	*See under* Emperador limestone member of La Boca formation, Gaillard Cut area.
119 to 120a	-------	--------	--------	*See under* La Boca formation, Gaillard Cut area.
121	-------	--------	--------	*See under* Emperador limestone member of La Boca formation, Gaillard Cut area.
				CUCARACHA FORMATION (EARLY MIOCENE)
122	122	6012e	--------	Near Canal station 1940. Entered in P 306–A.
122a	122a	19966	--------	No change. Entered in P 306–B.
122b	122b	--------	--------	Do.
122c	122c	23649	401	No change. Entered in P 306–D.
				LA BOCA FORMATION (EARLY MIOCENE), GAILLARD CUT AREA
	98	16942	35a	Canal station 1766. Originally assigned to Culebra formation. Entered in P 306–A.
				LA BOCA FORMATION (EARLY MIOCENE), GAILLARD CUT AREA—Continued
	99	6019	--------	Presumably near Canal station 1766. Originally assigned to Culebra formation. Entered in P 306–A.
	99a	6019a	--------	Near Canal station 1777. Originally assigned to Culebra formation. Entered in P 306–A.
	99b	6019b	--------	Do.
	99c	6019c	--------	Canal station 1776. Originally assigned to Culebra formation. Entered in P 306–A.
	99d	6019d	--------	Canal station 1775. Originally assigned to Culebra formation. Entered in P 306–A.
	99e	6019e	--------	Near Canal station 1774. Originally assigned to Culebra formation. Entered in P 306–A.
	99f	6019f	--------	Near Canal station 1773. Originally assigned to Culebra formation. Entered in P 306–A.
	99g	6019g	--------	Canal station 1772. Originally assigned to Culebra formation. Entered in P 306–A.
	99h	5857	--------	Near Canal station 1776. Originally assigned to Culebra formation. Entered in P 306–A.

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Consecutive order	Stratigraphic order			
				LA BOCA FORMATION (EARLY MIOCENE), GAILLARD CUT AREA—Continued
	100	6020a	--------	Near Canal station 1780. Originally assigned to Culebra formation. Entered in P 306–A.
	100a	6020b	--------	Do.
	100b	6020c	--------	Do.
	101	16943	34	Canal station 1785 Originally assigned to Culebra formation. Entered in P 306–A.
	101a	23650	412	Canal station 1793. Entered in P 306–D.
	101b	23651	416	Canal station 1797. Entered in P 306–D.
	101c	23656	410	Canal station 1788. Entered in P 306–D.
	101d	23668	410–2	Do.
	101e	23655	415	Canal station 1794. Entered in P 306–D.
	101f	23653	404	Canal station 1768. Entered in P 306–D.
	101g	23654	402	Canal station 1767. Entered in P 306–D.
	101h	23652	403	Canal station 1774 to 1778. Entered in P 306–D.
	101i	23658	413	Canal station 1788. Entered in P 306–D.
	101j	24744	--------	Panama Canal, west side of Las Cascadas Reach, somewhere between Canal stations 1779 and 1782, Canal Zone. A. A. Olsson and J. L. Stewart, 1969. New entry.
	102	6012a	--------	Near Canal station 1890. Originally assigned to Culebra formation. Entered in P 306–A.
	102a	6507	--------	Probably near Canal station 1887. Originally assigned to Culebra formation. Entered in P 306–A.
	113	6011	--------	Near Canal station 2013. Originally assigned to Culebra formation. Entered in P 306–A.
	114	5860	--------	Canal station 2015 plus 25 feet (7.5 m.) Originally assigned to Culebra formation. Entered in P 306–A.
	115	6505	--------	Near Canal station 2028. Originally assigned to Culebra formation. Entered in P 306–A.
	115a	6515	--------	No change. Originally assigned to Culebra formation. Entered in P 306–A.
	115b	6443	--------	Do.
	116	5853	--------	Canal station 2031. Originally assigned to Culebra formation. Entered in P 306–A.
	116a	20956	--------	Canal station 2038. Originally assigned to Culebra formation. Entered in P 306–C.
	119	5858	--------	No change. Originally assigned to Culebra formation. Entered in P 306–A.

No. used in this report		USGS Cenozoic No.	Field No.	Description of locality, remarks, corrections. [Only new entries are fully described. See P 306A–D for original locality descriptions]
Consecutive order	Stratigraphic order			
				LA BOCA FORMATION (EARLY MIOCENE), GAILLARD CUT AREA—Continued
	119a	5866	--------	Do.
	119b	6669	--------	Do.
	119c	5856	--------	Do.
	120	16958	35	Canal station 1766. Originally assigned to Culebra formation. Entered in P 306–A.
	120a	8043	--------	Canal station 1600. Originally assigned to Culebra formation. Entered in P 306–A.
123	-------	--------	--------	*See under* Emperador limestone member of La Boca formation.
124	124	--------	32	Canal station 1869. Entered in P 306–A.
125	125	5852	--------	Near Canal station 1876. Entered in P 306–A.
126 to 128	-------	--------	--------	*See under* La Boca formation, Summit area.
129	-------	--------	--------	*See under* Emperador limestone member of La Boca formation.
129a	129a	16953	14	No change. Entered in P 306–A.
130	-------	--------	--------	*See under* La Boca formation, Pedro Miguel area.
131 & 131a	-------	--------	--------	*See under* Emperador limestone member of La Boca formation.
132	132	16939	57	No change. Entered in P 306–A.
				LA BOCA FORMATION (EARLY MIOCENE), LAS CRUCES AREA
	94	6509	--------	No change. Originally assigned to Caimito formation. Entered in P 306–A.
	94a	6510	--------	Do.
				LA BOCA FORMATION (EARLY MIOCENE), SUMMIT AREA
	126	6267	--------	Discarded. Entered in P 306–A.
	127	6018	--------	No change. Entered in P 306–A.
	127a	6268	--------	Do.
	127b	6336	--------	Do.
	128	16947	4	Do.
				LA BOCA FORMATION (EARLY MIOCENE) PEDRO MIGUEL AREA
	130	6010	--------	Near Canal station 2078. Entered in P 306–A.
				LA BOCA FORMATION (EARLY MIOCENE) MADDEN BASIN
	75	17437	133	No change. Originally assigned to Caimito formation. Entered in P 306–A.
				EMPERADOR LIMESTONE MEMBER OF LA BOCA FORMATION (EARLY MIOCENE), GAILLARD CUT AREA AND NEARBY
	117	6014	--------	Discarded. Entered in P 306–A.

No. used in this report		USGS Cenozoic No.	Field No.	Description of locality, remarks, corrections. [Only new entries are fully described. See P 306A–D for original locality descriptions]
Consecutive order	Stratigraphic order			
				EMPERADOR LIMESTONE MEMBER OF LA BOCA FORMATION (EARLY MIOCENE), GAILLARD CUT AREA AND NEARBY—Continued
	117a	23662	414a	Canal station 1796. Entered in P 306–D.
	117b	23661	414	Do.
	117c	23660	417	West side instead of east. Canal station 1792. Entered in P 306–D.
	117d	23657	410–3	Canal station 1788. Entered in P 306–D.
	118	6016	--------	No change. Entered in P 306–A. Type locality of Emperador limestone member.
	118a	6444	--------	Locality 117 instead of 118. Entered in P 306–A.
	118b	23659	--------	Same locality as 118. Erroneously entered in P 306–D as 118.
	121	16941	34a	Canal station 1785. Entered in P 306–A.
	123	16955	33	Canal station 1863. Entered in P 306–A.
	129	16954	14a	No change. Entered in P 306–A.
	131	6256	--------	Do.
	131a	6257	--------	Do.
132a	132a	6255	--------	Discarded. Entered in P 306–A.
133	133	6237	--------	Do.
				EMPERADOR LIMESTONE MEMBER OF LA BOCA FORMATION (EARLY MIOCENE), MADDEN BASIN
	71	16945	6	No change. Originally assigned to Caimito formation. Entered in P 306–A.
	72	16957	40	Do.
	73	16944	7	Do.
				LOWER MEMBER OF ALHAJUELA FORMATION (EARLY MIOCENE), MADDEN BASIN
	65	5907	--------	No change. Originally assigned to Caimito formation. Entered in P 306–A.
	66	8386	--------	Do.
	66a	25781	--------	Little islet in Madden Lake, 300 m south-southeast of Vigía Island. Emerges only when level of Madden Lake is below 212 feet (65 m). Limestone. R. H. Stewart, 1974. New entry.
	74	17439	142	Conglomerate at base of Alhajuela formation. Originally assigned to Caimito formation. Entered in P 306–A.
	74a	17493	142a	No change. Originally assigned to Caimito formation. Entered in P 306–A.
	76	5906a	--------	Do.
	76a	5906b	--------	Discarded. Originally assigned to Caimito formation. Entered in P 306–A.

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Consecutive order	Stratigraphic order			
				LOWER MEMBER OF ALHAJUELA FORMATION (EARLY MIOCENE), MADDEN BASIN—Continued
	77	5905	--------	No change. Originally assigned to Caimito formation. Entered in P 306–A.
	78	8399	--------	Do.
	79	8398	--------	Do.
	80	7289	--------	Do.
	81	16932	24	Do.
	82	16929	8	Do.
	82a	17494	8a	Do.
	83	16930	10	Do.
	84	17491	10a	Do.
	84a	17492	10b	Do.
				UPPER MEMBER OF ALHAJUELA FORMATION (EARLY MIOCENE), MADDEN BASIN
	85	5903	--------	No change. Originally assigned to Caimito formation. Entered in P 306–A.
	85a	8385	--------	Do.
	86	5904	--------	Do.
	87	5874	--------	Do.
	88	17682	143	Do.
	89	16956	17	Do.
	90	17683	144	Do.
	90a	17684	144a	Do.
	91	16952	9	Do.
	92	16940	16	Do.
				LOWER PART OF GATUN FORMATION (MIDDLE MIOCENE)
134	134	17691	102	No change. Entered in P 306–A.
135	135	17690	101	Do.
136	136	16912	12	Do.
136a	136a	--------	--------	Do.
				LOWER PART OF GATUN FORMATION (MIDDLE MIOCENE)—Continued
137	137	16911	26	Do.
137a	137a	--------	--------	Do.
138	138	16909	27	Do.
138a	138a	--------	--------	Do.
138b	138b	19853	--------	No change. Entered in P 306–B.
138c	138c	21956	--------	No change. Entered in P 306–C.
138d	138d	22016	302	Do.
138e	138e	22391	--------	Do.
138f	138f	23663	406	No change. Entered in P 306–D.
138g	138g	23664	407	Do.
138h	138h	25281	603	Cut on south side of cart track leading past house on road to Refinería Las Minas, near Transisthmian Highway, Panamá. R. H. Stewart, J. L. Stewart, and W. P. Woodring, 1973. New entry.
138i	138i	25280	602	Hillside cut in housing development on north side of Transisthmian Highway 1.5 km southeast of Cativa, Panamá. R. H. Stewart, J. L. Stewart, and W. P. Woodring, 1973. New entry.
				MIDDLE PART OF GATUN FORMATION (MIDDLE MIOCENE), EASTERN AREA
139	139	6667	--------	No change. Entered in P 306–A as lower part of Gatun formation.
139a	139a	21844	--------	No change. Entered in P 306–C.

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Consecutive order	Stratigraphic order			
				MIDDLE PART OF GATUN FORMATION (MIDDLE MIOCENE), EASTERN AREA—Continued
139b	139b	22017	--------	Do.
139c	139c	22018	303	Do.
139d	139d	22390	--------	Do.
139e	139e	22019	--------	Do.
139f	139f	22020	301	Do.
139g	139g	22417	--------	Do.
139h	139h	25278	600	Hillside cut in housing development on south side of Transisthmian Highway adjoining Canal Zone boundary, Panamá. Altitude about 15 m. R. H. Stewart, J. L. Stewart, and W. P. Woodring, 1973. New entry.
139i	139i	25279	601	Same locality as 139h, but closer to Canal Zone boundary and altitude about 6 m. R. H. Stewart, J. L. Stewart, and W. P. Woodring, 1973. New entry.
140	140	--------	--------	No change. Entered in P 306–A.
141	141	16948	28	Do.
142	142	--------	--------	Do.
143	143	6030	--------	Camp Totten instead of Camp Cotton. Entered in P 306–A.
143a	143a	24504	--------	No change. Entered in P 306–D.
144	144	6029a	--------	Camp Totten instead of Camp Cotton. Entered in P 306–A.
144a	144a	6029b	--------	No change. Entered in P 306–A.
144b	144b	6335	--------	Camp Totten instead of Camp Cotton. Entered in P 306–A.
				MIDDLE PART OF GATUN FORMATION (MIDDLE MIOCENE), EASTERN AREA—Continued
144c	144c	6235	--------	No change. Entered in P 306–A.
144d	144d	6334	--------	Camp Totten instead of Camp Cotton. Entered in P 306–A.
145	145	6031	--------	Do.
146	146	5845	--------	No change. Entered in P 306–A.
147	147	6033a		Do.
147a	147a	6033b	--------	Do.
147b	147b	6033c	--------	Do.
147c	147c	6003	--------	Do.
147d	147d	6004	--------	Do.
147e	147e	6005	--------	Do.
147f	147f	6006	--------	Do.
147g	147g	5899	--------	Do.
147h	147h	6442	--------	Do.
147i	147i	8376	--------	Do.
147j	147j	8379	--------	Do.
148	148	8380	--------	Do.
149	149	8381	--------	Do.
150	150	8377	--------	Do.
150a	150a	10997	--------	Do.
151	151	8388	--------	Do.
152	152	8483	--------	Do.
153	153	16950	47	Do.
153a	153a	--------	--------	Do.
154	154	16935	48	Do.
155	155	--------	--------	Do.
155a	155a	16970	--------	Do.
155b	155b	16949	49	Do.
155c	155c	16915	50	Do.
156	156	16928	13	Do.
157	157	16926	56	Do.
158	158	2682	17	Vamos á Vamos, Canal Zone. R. T. Hill, 1895. [Locality erroneous; it should be French Canal, about half a mile (800 m) south (southeast) of Gatun.]

No. used in this report		USGS Cenozoic No.	Field No.	Description of locality, remarks, corrections. [Only new entries are fully described. See P 306A–D for original locality descriptions]
Consecutive order	Stratigraphic order			
				MIDDLE PART OF GATUN FORMATION (MIDDLE MIOCENE), EASTERN AREA—Continued
159	159	5211	--------	Lock site at Gatun. Entered in P 306–A.
159a	159a	5414	--------	No change. Entered in P 306–A.
159b	159b	6273	--------	Do.
159c	159c	5662	--------	Do.
159d	159d	24173	--------	No change. Entered in P 306–D.
				MIDDLE PART OF GATUN FORMATION (MIDDLE MIOCENE), WESTERN AREA
160	160	5846	--------	No change. Entered in P 306–A under eastern area.
160a	160a	8369	--------	Do.
160b	160b	23665	408	No change. Entered in P 306–D.
160c	160c	23666	409	Do.
160d	160d	24503	--------	Do.
161	161	8365	--------	No change. Entered in P 306–A.
161a	161a	8395	--------	Do.
161b	161b	8375	--------	Do.
161c	161c	8382	--------	Do.
161d	161d	8366	--------	Do.
162	162	8396	--------	Do.
162a	162a	8359	--------	Do.
163	--------	--------	--------	*See under* upper part of Gatun formation, eastern area.
164	164	8391	--------	No change. Entered in P 306–A.
165	165	8372	--------	Do.
166	166	8357	--------	Do.
167	167	8374	--------	Do.
168	168	8361	--------	Do.
169	169	8360	--------	Do.
170	170	8368	--------	Do.
170a	170a	8411	--------	Headwaters instead of headquarters. Entered in P 306–A.

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Consecutive order	Stratigraphic order			
				UPPER PART OF GATUN FORMATION (MIDDLE MIOCENE), EASTERN AREA
	163	8394	--------	No change. Entered in P 306–A.
171	171	--------	--------	Do.
172	172	6035	--------	Do.
173	173	--------	--------	Do.
173a	173a	2689	48	Do.
174	174	2688, 2690	29, 49	Do.
175	175	8410	--------	Do.
176	176	8358	--------	Do.
176a	176a	8409	--------	Do.
177	177	--------	--------	Do.
177a	177a	4895	--------	Do.
177b	177b	5854	--------	Do.
177c	177c	5855	--------	Do.
177d	177d	6036	--------	Do.
177e	177e	24174	--------	No change. Entered in P 306–D.
177f	177f	--------	--------	Bland's or Rowell's collection from Monkey Hill [Mount Hope], mislabelled Ponton, Dominican Republic. New entry.
178	178	--------	--------	No change. Entered in P 306–A.
				UPPER PART OF GATUN FORMATION (MIDDLE MIOCENE), WESTERN AREA, ORIGINALLY ASSIGNED TO LATE MIOCENE.
179	179	8413	--------	No change. Entered in P 306–A.
180	180	8362	--------	Do.
181	181	8364	--------	Do.
182	182	8408	--------	Do.
182a	182a	8488	--------	Do.
183	183	8487	--------	Do.
184	184	8363	--------	Do.
185	185	8383	--------	Do.

No. used in this report		USGS Cenozoic No.	Field No.	Description of locality, remarks, corrections. [Only new entries are fully described. See P 306A–D for original locality descriptions]
Consecutive order	Stratigraphic order			
				TORO LIMESTONE MEMBER OF CHAGRES SANDSTONE (LATE MIOCENE OR EARLY PLIOCENE), ORIGINALLY ASSIGNED TO EARLY PLIOCENE
186	186	6037	--------	No change. Entered in P 306–A.
186a	186a	6675	--------	Do.
186b	186b	8440	--------	Do.
187	187	--------	--------	Do.
188	188	16946	51	Do.
188a	188a	5909	--------	Do.
188b	188b	6034	--------	Do.
188c	188c	6668	--------	Do.
188d	188d	6236	--------	Do.
188e	188e	8442	--------	Do.
189	189	8392	--------	Do.
190	190	8402	--------	Do.
191	191	8371	--------	Do.
192	192	8404	--------	Do.
193	193	8401	--------	Do.
194	194	8373	--------	Do.
195	195	8403	--------	Do.
196	196	8405	--------	Do.
				CHAGRES SANDSTONE PROPER (LATE MIOCENE OR EARLY PLIOCENE), ORIGINALLY ASSIGNED TO EARLY PLIOCENE
197	197	8482	--------	No change. Entered in P 306–A.
198	198	8484	--------	Do.
199	199	8443	--------	Do.
200	200	8406	--------	Do.
201	201	8439	--------	Do.
202	202	8389	--------	Do.
203	203	8436	--------	Do.
204	204	8441	--------	Do.
205	205	8387	--------	Do.
				CHAGRES SANDSTONE PROPER (LATE MIOCENE OR EARLY PLIOCENE), ORIGINALLY ASSIGNED TO EARLY PLIOCENE—Continued
206	206	16937	52	Do.
206a	206a	--------	--------	Do.
206b	206b	16938	52a	Do.
207	207	16969	--------	Do.
208	208	8437	--------	Do.

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PLATES 83–124

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PLATE 83

FIGURES 1, 4. *Fimbria jamaicensis* (Trechmann) (p. 624).

1. Left valve. Length about 83 mm. Locality 11. USNM 647362.
4. Latex cast of left valve. Length (practically complete) 59.5 mm. Locality 11. USNM 647365.

2, 6. *Fimbria* cf. *F. vernoni* Richards (p. 624).

2. Right valve of articulated specimen. Length 51.5 mm. Locality 12. USNM 647364.
6. Right valve of articulated specimen. Length 60.4 mm. Locality 12. USNM 647363.

3, 5. *Schedocardia*? *gatunensis samanica* (Olsson) (p. 635).

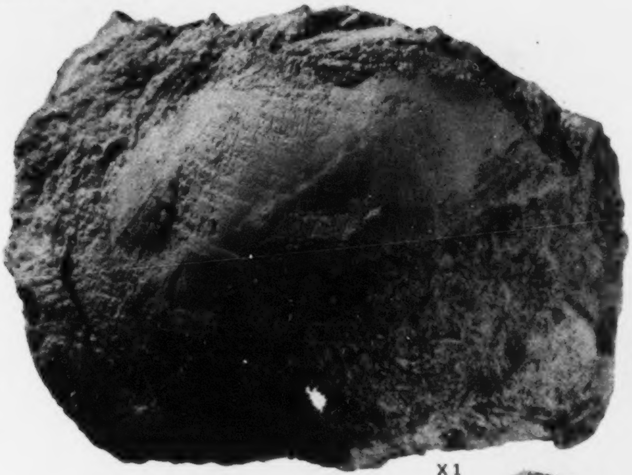
3. Latex cast of left valve. Length (incomplete) 28 mm. Locality 37a. USNM 647431.
5. Latex cast of left valve. Length 21.5 mm. Locality 37a. USNM 647432.

7, 9. *Spondylus olssoni* Clark (p. 600).

7. Almost equilateral right valve. Length 77 mm. Locality 32. USNM 647239.
9. Decidedly inequilateral right valve. Length 73 mm. Locality 32. USNM 647240.

8. *Schedocardia*? sp. (p. 635).

Right valve. Length 35 mm. Locality 11. USNM 647430.



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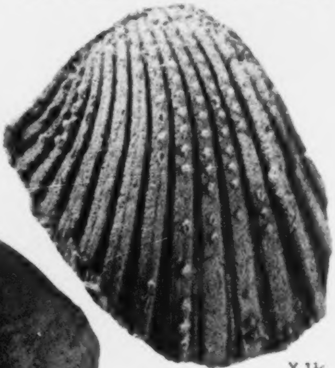

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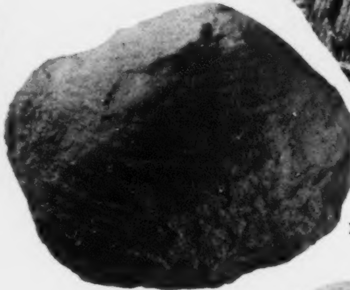

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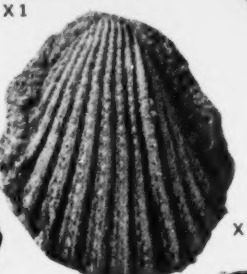

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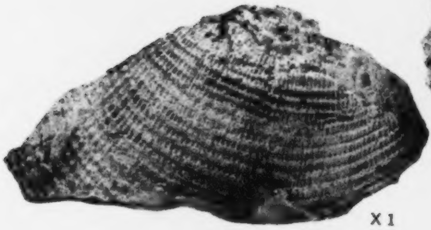

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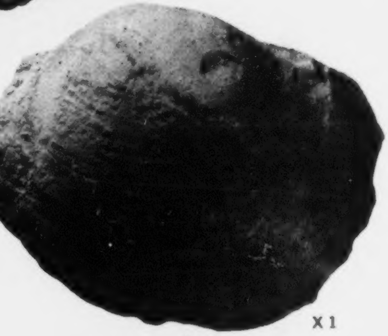

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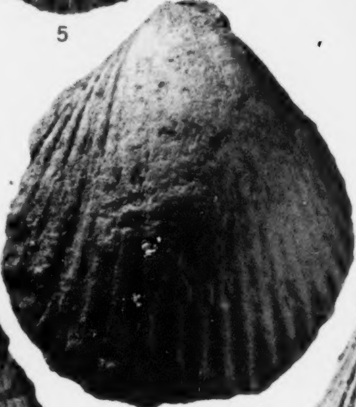

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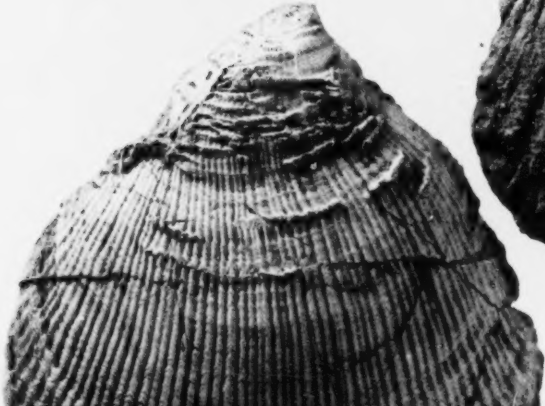

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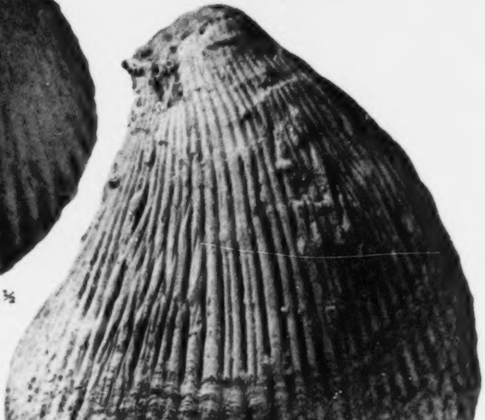

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LATE EOCENE MOLLUSKS FROM GATUNCILLO FORMATION

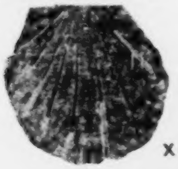
PLATE 84

FIGURE 1. *Propeamussium* sp. (p. 577).
Right valve. Length 4.8 mm. Locality 35. USNM 647208.

2. *Venericardia* (*Rotundicardia*) sp. (p. 627).
Left valve. Length 13 mm. Locality 38. USNM 647376.

3. *Velates perversus* (Gmelin) (p. 724).
19 cm. Locality 12a. USNM 647807.

4–6. *Plastomiltha*? *odontota* Woodring, n. sp. (p. 616).
4, 6. Paratype, right valve. Length 26 mm. Locality 23b. USNM 647336.
5. Type, right valve of articulated specimen. Length 30.3 mm. Locality 23b. USNM 647335.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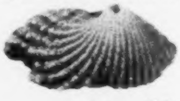
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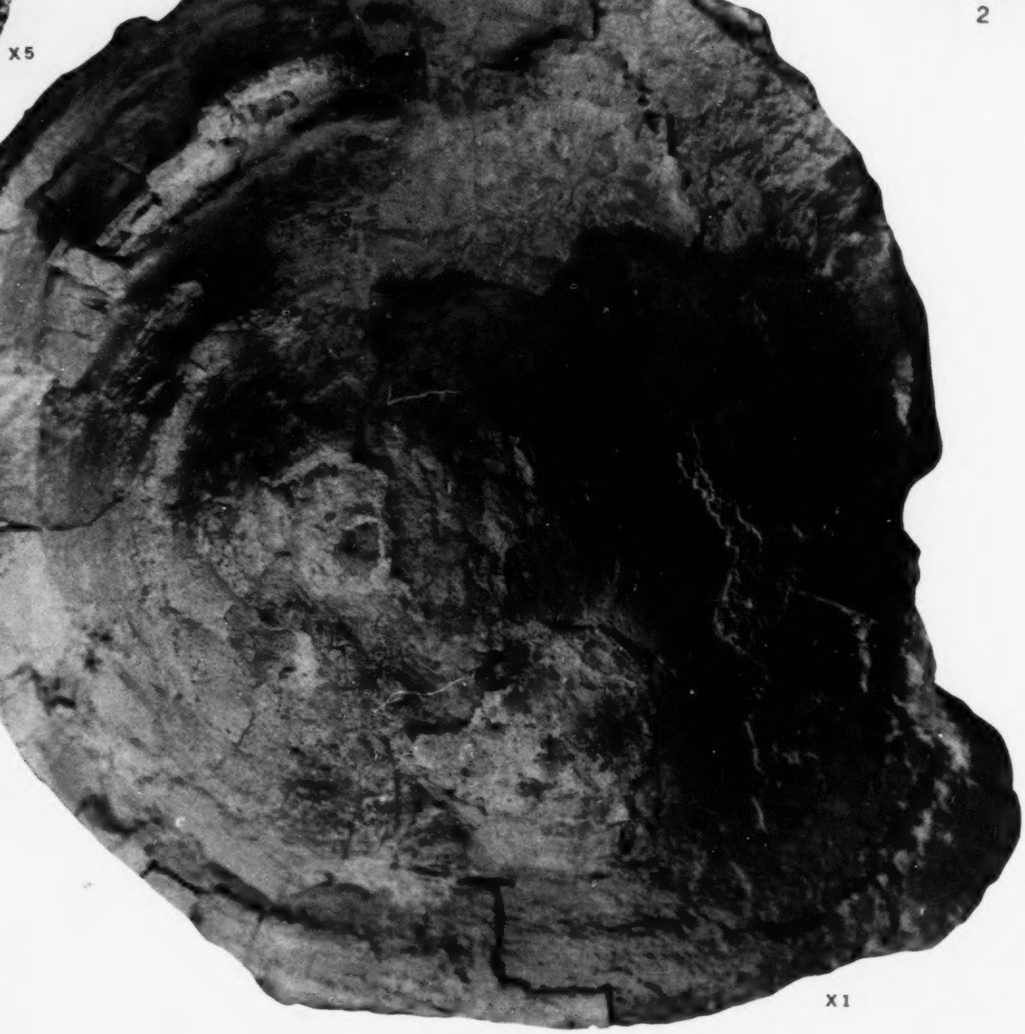
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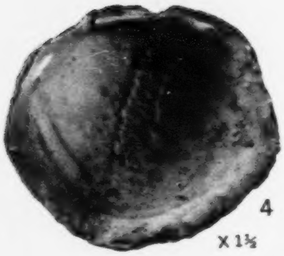
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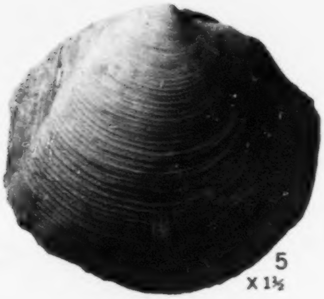
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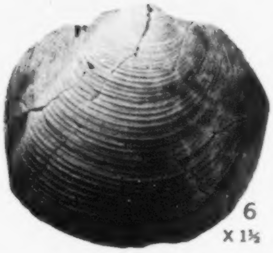
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MIDDLE AND LATE EOCENE MOLLUSKS FROM GATUNCILLO FORMATION

PLATE 85

FIGURE 1. *Tellina* (*Arcopagia*) cf. *T. eburneopsis* Conrad (p. 657).
Left valve of internal mold of articulated specimen. Length 20.3 mm. Locality 9. USNM 647538.

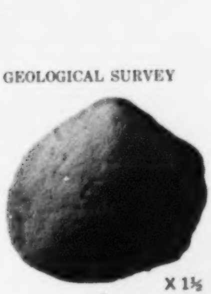
2. *Tellina* (*Eurytellina*?) sp. (p. 661).
Right valve of internal mold of articulated specimen. Length 20.5 mm. Locality 9. USNM 647546.

3. *Megalocypraea* aff. *M. clarki* (Ingram) (p. 725).
Height 16.8 cm. Locality 5a. USNM 647808.

4. *Pitar* (*Pitar*?) *carmenensis* Clark (p. 684).
Left valve of internal mold of articulated specimen. Length 23.5 mm. Locality 12. USNM 647647.

5, 7, 8. *Anomia* cf. *A. lisbonensis* Aldrich (p. 603).
5, 8. Left valve. Length 31.5 mm. Locality 23b. USNM 647241.
7. Exceptionally large left valve, length 40 mm. Locality 23b. USNM 647242.

6. *Cytheriopsis conradi* (Clark) (p. 683).
Right valve. Length 40.5 mm. Locality 6. USNM 647643.



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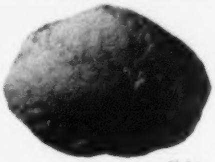

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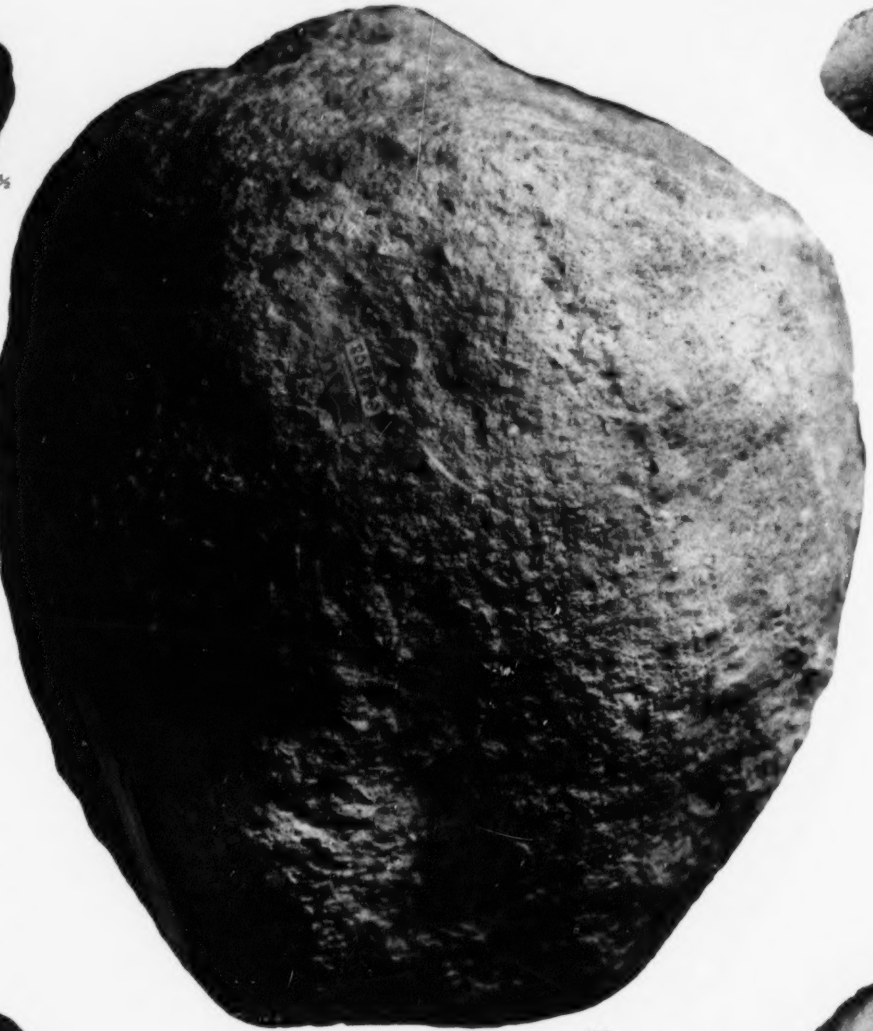

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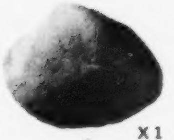

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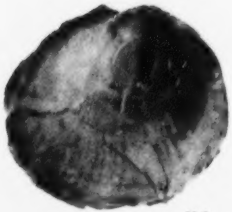

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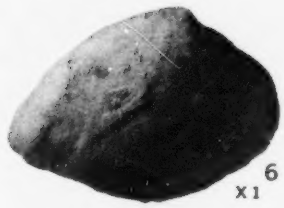

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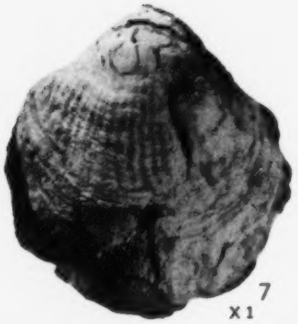

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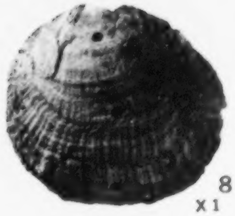

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LATE EOCENE MOLLUSKS FROM GATUNCILLO FORMATION

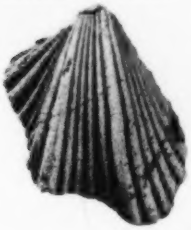
PLATE 86

FIGURES 1, 2. *Chrysocardium aurum* Woodring, n. sp. (p. 641).
Type, left valve. Length 18.5 mm. Locality 38. USNM 647478.

3. *Megalocypraea* aff. *M. clarki* (Ingram) (p. 725).
Height 16.8 cm. Locality 5a. USNM 647808.

4, 5. *Bathytormus* sp. (p. 632).
  4. Latex cast of left valve. Length 31.3 mm. Locality 37a. USNM 647419.
  5. Latex cast of right valve. Length 29.5 mm (almost complete). Locality 37a. USNM 647420.

6. *Lithophaga* (*Lithophaga*) *nigra* (d'Orbigny) (p. 724).
Length 39.3 mm. Locality 11. USNM 647207



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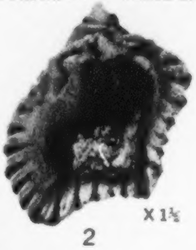

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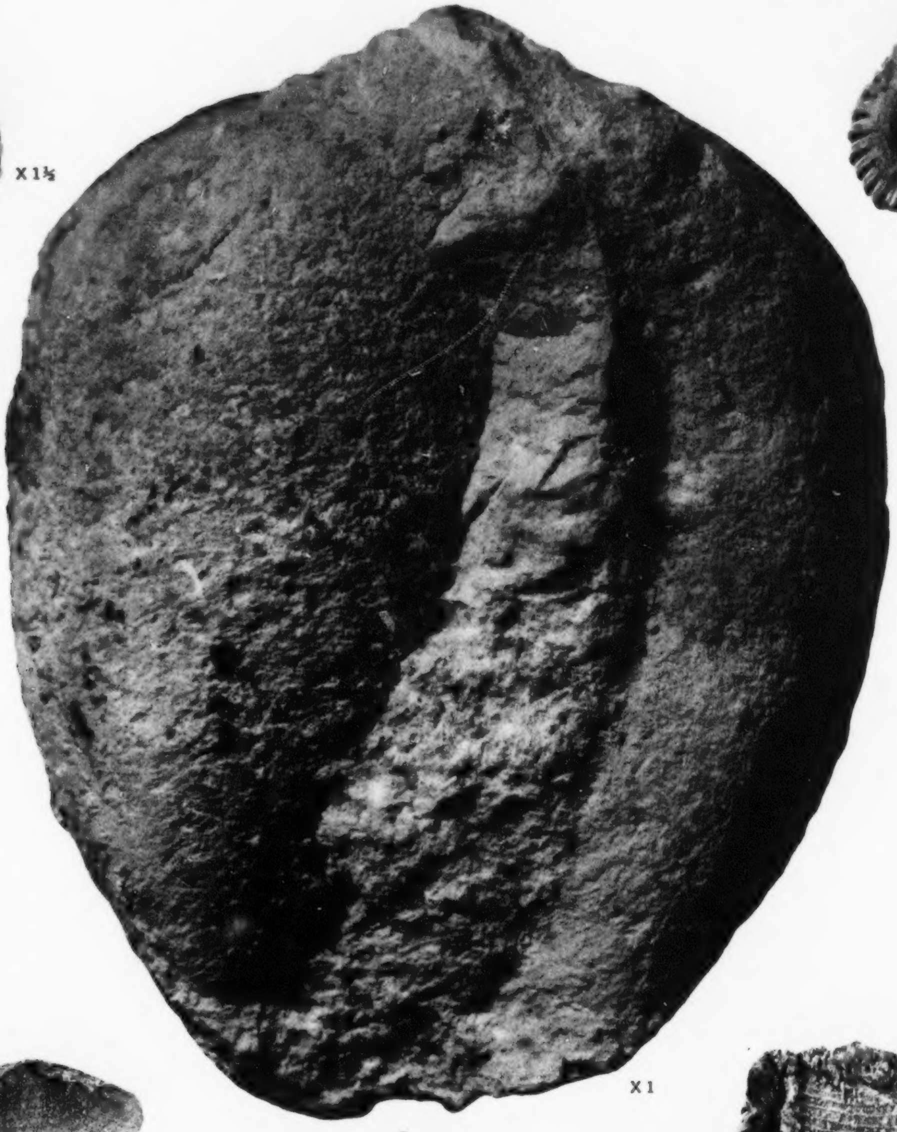

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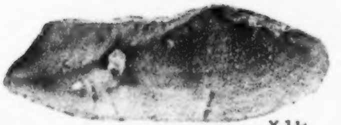

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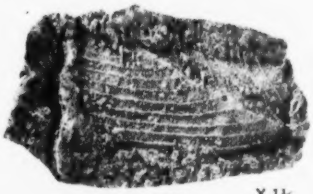

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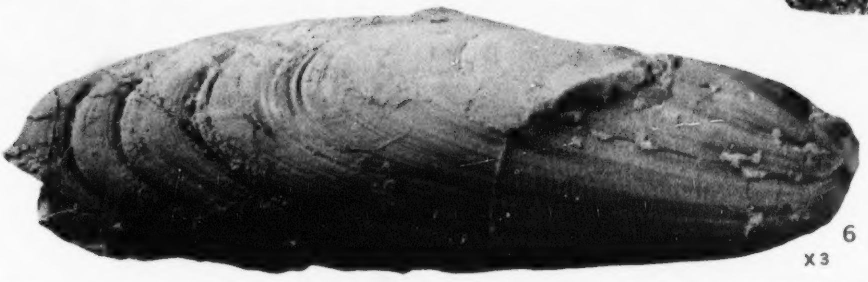

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MIDDLE AND LATE EOCENE MOLLUSKS FROM GATUNCILLO FORMATION

PLATE 87

FIGURES 1, 2. *Ovamactra cyma* Woodring, n. sp. (p. 651).
- 1. Immature right valve. Length 21.9 mm. Locality 41a. USNM 647517.
- 2. Type, right valve. Length 30.5 mm. Locality 40a. USNM 135235.

3, 5, 6, 10. *Eopapyrina darienensis* (Dall) (p. 649).
- 3, 5. Right valve. Length 23 mm. Locality 41. USNM 647513.
- 6. Type, right valve. Length (almost complete) 21 mm. Locality 40. USNM 112271.
- 10. Right valve. Length (almost complete) 30 mm. Locality 41b. USNM 647512.

4, 9. *Lamelliconcha hillii* (Dall) (p. 688).
- 4. Lectotype, designated on p. 688, right valve. Length (almost complete) 33 mm. Locality 40a. USNM 135252.
- 9. Left valve. Length (almost complete) 34 mm. Locality 42. USNM 647690.

7. *Ervilia* sp. (p. 654).
Left valve. Length 6.2 mm. Locality 41b. USNM 647526.

8. *Schedocardia*? *gatunensis gatunensis* (Dall) (p. 636).
Lectotype, designated on p. 636, right valve. Length 23 mm. Locality 40a. USNM 135241.

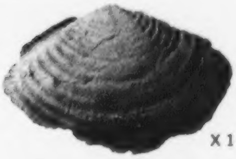
11. *Semele* sp. (p. 675).
Right valve. Length 39 mm. Locality 41b. USNM 647610.

12. *Pisidium atopum* Woodring, n. sp. (p. 679).
Type, right valve. Length 10.6 mm. Locality 42f. USNM 647725.

13. *Argopecten*? sp. (p. 596).
Right valve. Length 26.4 mm. Locality 60. USNM 647210.

14. *Venericardia* (*Rotundicardia*?) sp. (p. 627).
Left valve. Length 13.5. Locality 41. USNM 647377.

15. *Flabellipecten gatunensis protistus* Woodring, n. subsp. (p. 583).
Paratype, thick-shelled left valve. Length (almost complete) 66 mm. Locality 60. USNM 646977.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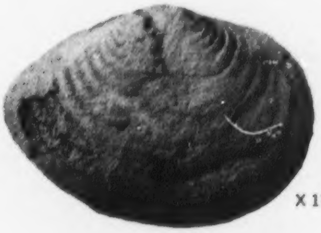
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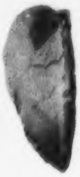
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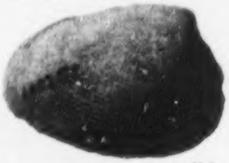
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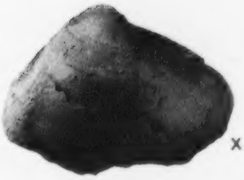
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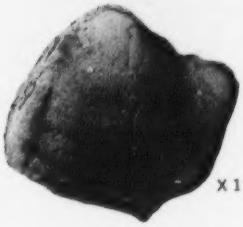
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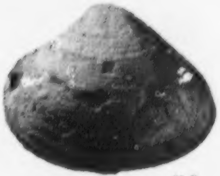
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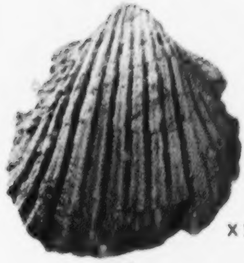
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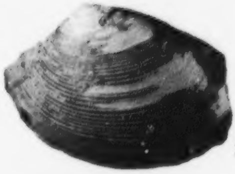
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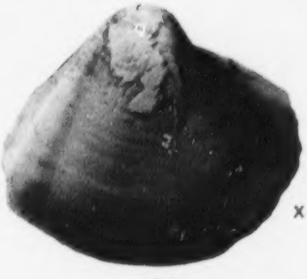
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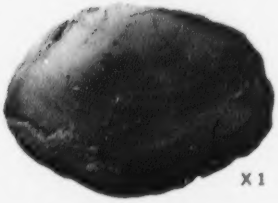
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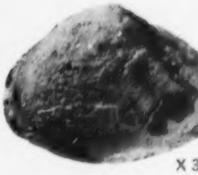
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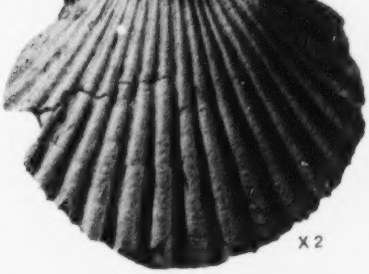
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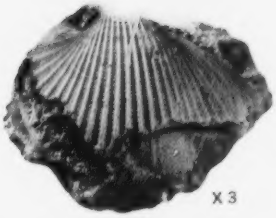
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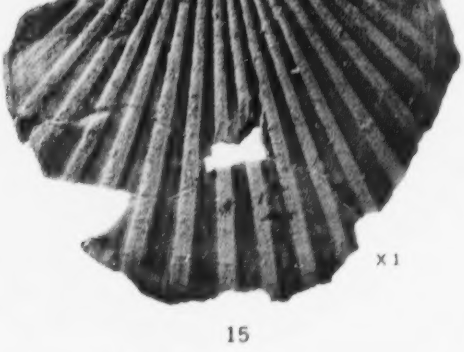
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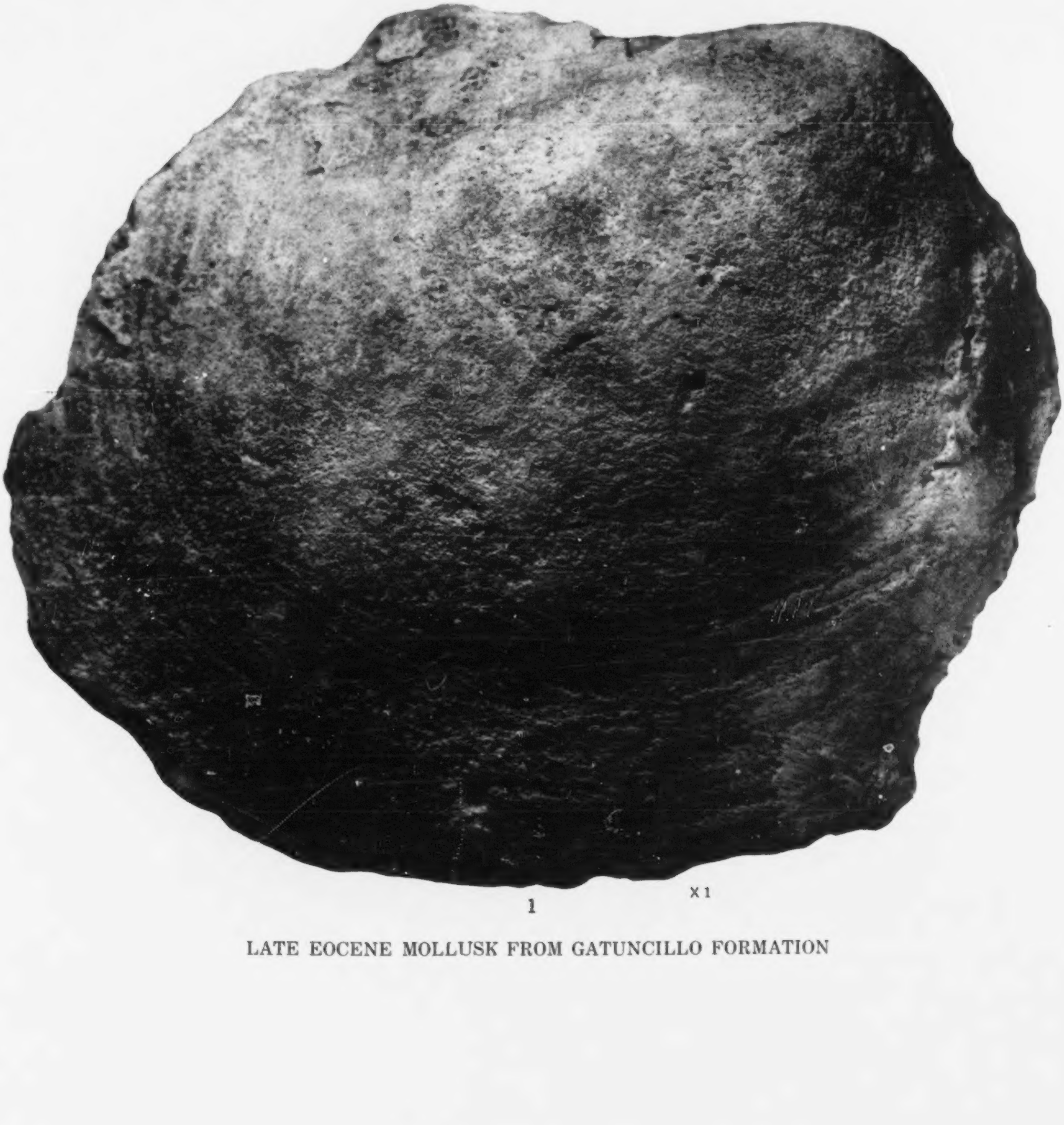
15

LATE EOCENE MOLLUSKS FROM MARINE ROCKS AND LATE OLIGOCENE MOLLUSKS FROM BOHIO FORMATION (FIG. 12) AND CARABA FORMATION (FIGS. 13, 15)

PLATE 88

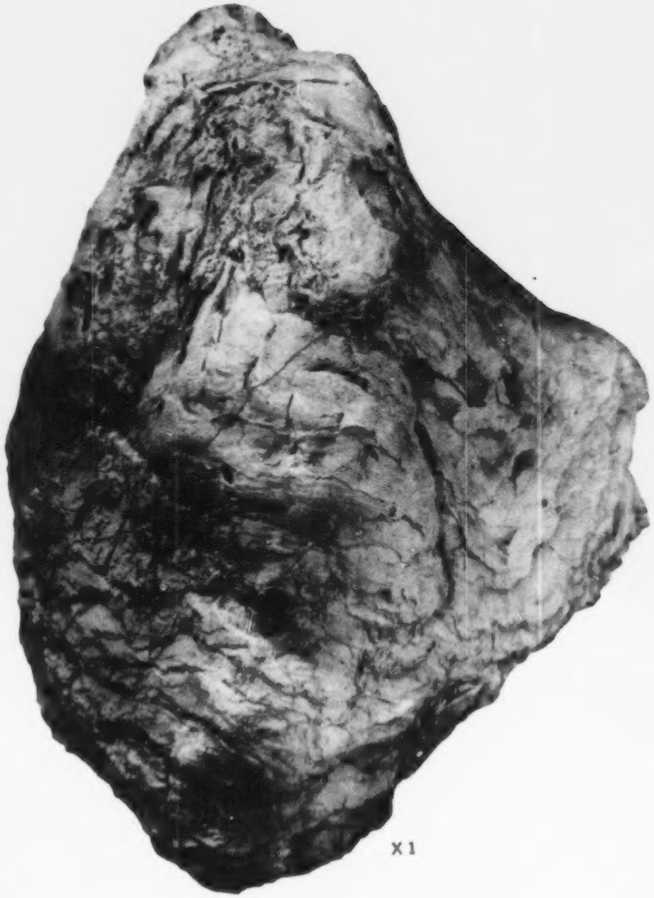
FIGURE 1. *Pseudomiltha megameris* (Dall) (p. 620).
Right valve of chiefly internal mold of articulated specimen. Length 19 cm. Locality 9. USNM 647314.



LATE EOCENE MOLLUSK FROM GATUNCILLO FORMATION

PLATE 89

Figures 1, 2. *Pycnodonte (Crenostrea) achanes* Woodring, n. sp. (p. 606).
1. Paratype, left valve. Length 94 mm. Locality 32. USNM 647277.
2. Type, left valve. Length 117 mm. Locality 32. USNM 647276.



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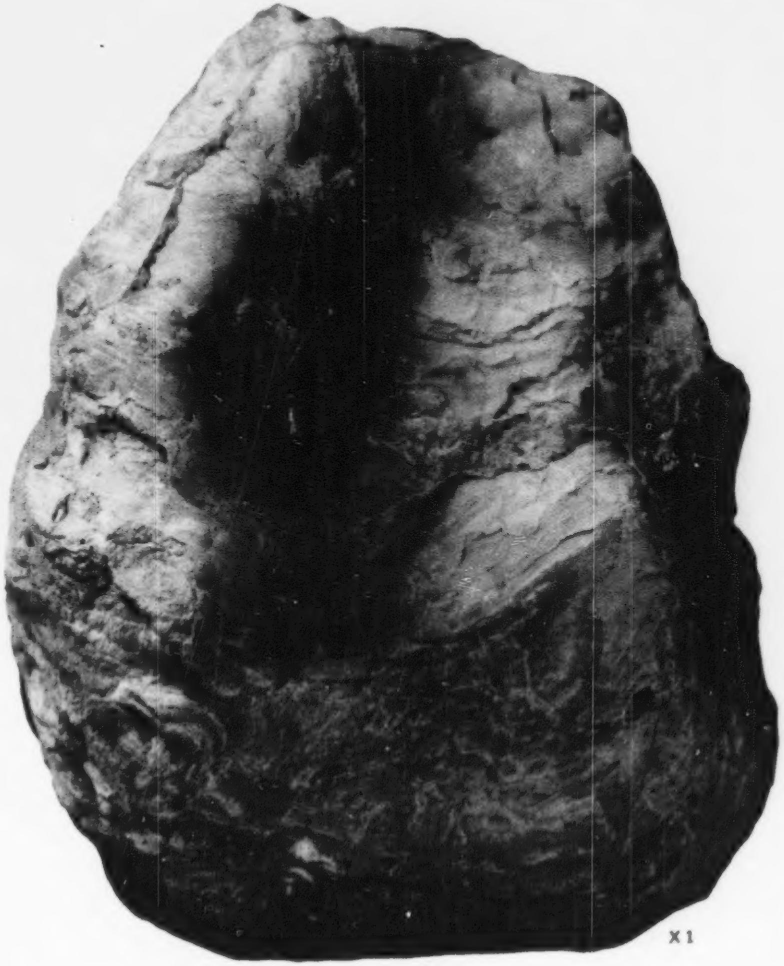


2

LATE EOCENE MOLLUSKS FROM GATUNCILLO FORMATION

PLATE 90

FIGURE 1. *Tellina* (*Angulus*?) sp. (p. 665).
Left valve. Length 5.8 mm. Locality 40d. USNM 647580.

2. *Lucinisca protista* Woodring, n. sp. (p. 617).
Type, left valve. Length 7.7 mm. Locality 42. USNM 647626.

3, 4, 8, 9. *Parastarte*? sp. (p. 708).
- 3. Right? valve. Length 1.9 mm.
- 4. Right valve. Length 1.3 mm.
- 8. Left valve. Length 1.5 mm.
- 9. Left valve. Length 1.4 mm. All locality 41. All USNM 647742.

5, 6. *Tellina* (*Arcopagia*?) *acares* Woodring, n. sp. (p. 657).
- 5. Type, left valve. Length 9 mm. Locality 41b. USNM 647578.
- 6. Paratype, right valve. Length 7.9 mm. Locality 41b. USNM 647579.

7, 13. *Gari* (*Gobraeus*) *listrota listrota* Woodring, n. sp. and subsp. (p. 672).
- 7. Paratype, right valve. Length (almost complete) 40 mm. Locality 41. USNM 647601.
- 13. Type, right valve. Length 34.5 mm. Locality 40a. USNM 135238.

10, 11. *Tellina* (*Eurytellina*) *alincia* Woodring, n. sp. (p. 661).
- 10. Paratype, right valve. Length 15.9 mm. Locality 40a. USNM 135233.
- 11. Type, right valve. Length (incomplete) 15.5 mm. Locality 42. USNM 647547.

12, 14. *Strigilla* (*Strigilla*) *protera* Woodring, n. sp. (p. 666).
- 12. Type, right valve. Length (incomplete) 6 mm. Locality 40d. USNM 647583.
- 14. Paratype, right valve. Length 6.7 mm. Locality 40d. USNM 647584.

15, 16. *Trachycardium* (*Dallocardia*) cf. *T.* (*D.*) *dominicense* (Gabb) (p. 638).
- 15. Left valve. Length 25.9 mm. Locality 42d. USNM 647454.
- 16. Right valve. Length 13.5 mm. Locality 42d. USNM 647455.

17. *Costacallista gabrielensis* (Clark) (p. 691).
Left valve. Length (practically complete) 42.5 mm. Locality 40a. USNM 135253.

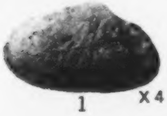
18. *Microcardium microtatum* Woodring, n. sp. (p. 645).
Type, right valve. Length 7.6 mm. Locality 41b. USNM 647503.

19, 20. *Varicorbula baea* Woodring, n. sp. (p. 715).
Type, articulated specimen. Right valve, length (incomplete) 3.6 mm. Left valve, length 3.6 mm. Locality 42. USNM 647762.

21. *Crassostrea cahobasensis* (Pilsbry and Brown) (p. 610).
Right valve. Length 53 mm. Locality 42f. USNM 647286.

22. *Pitar* (*Pitar*?) *yasila* (Olsson) (p. 685).
Right valve. Length 56.5 mm. Locality 40a. USNM 135255.

23–25. *Caryocorbula phruda* Woodring, n. sp. (p. 710.)
- 23, 24. Type, left valve. Length 15 mm. Locality 40d. USNM 647748.
- 25. Paratype, right valve. Length 15 mm. Locality 40a. USNM 647749.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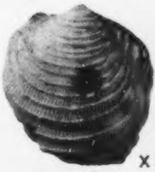
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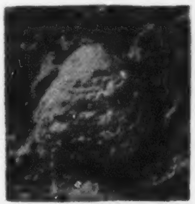
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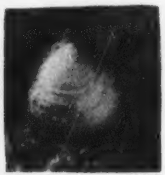
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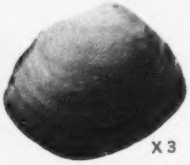
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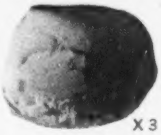
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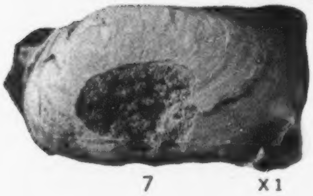
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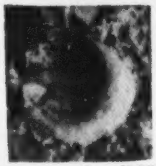
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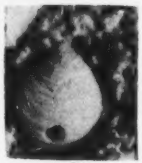
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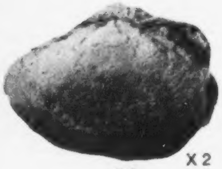
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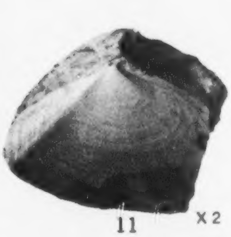
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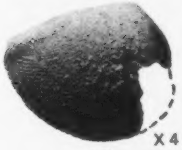
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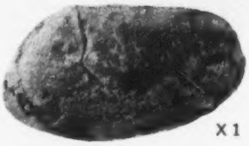
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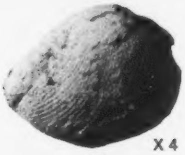
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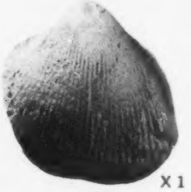
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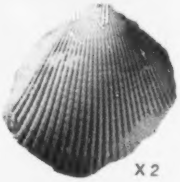
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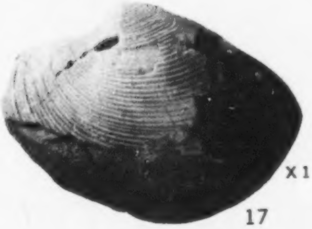
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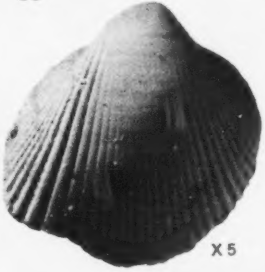
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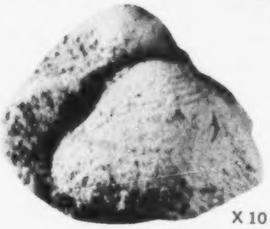
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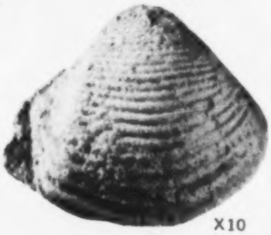
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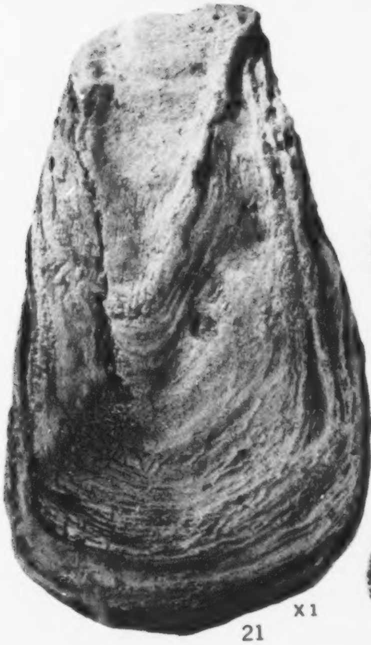
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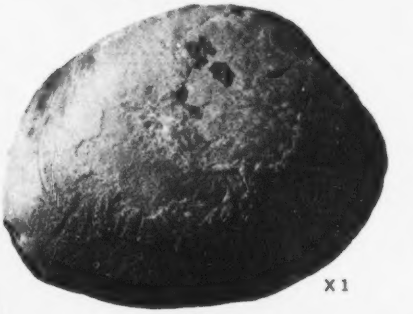
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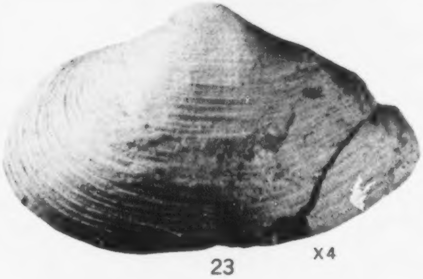
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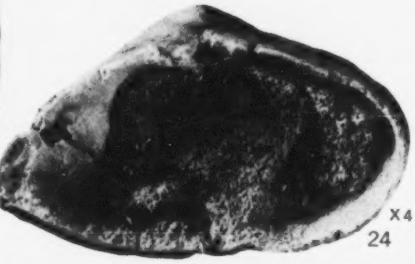
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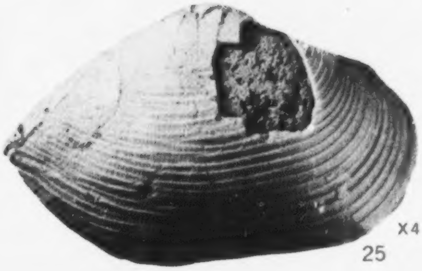
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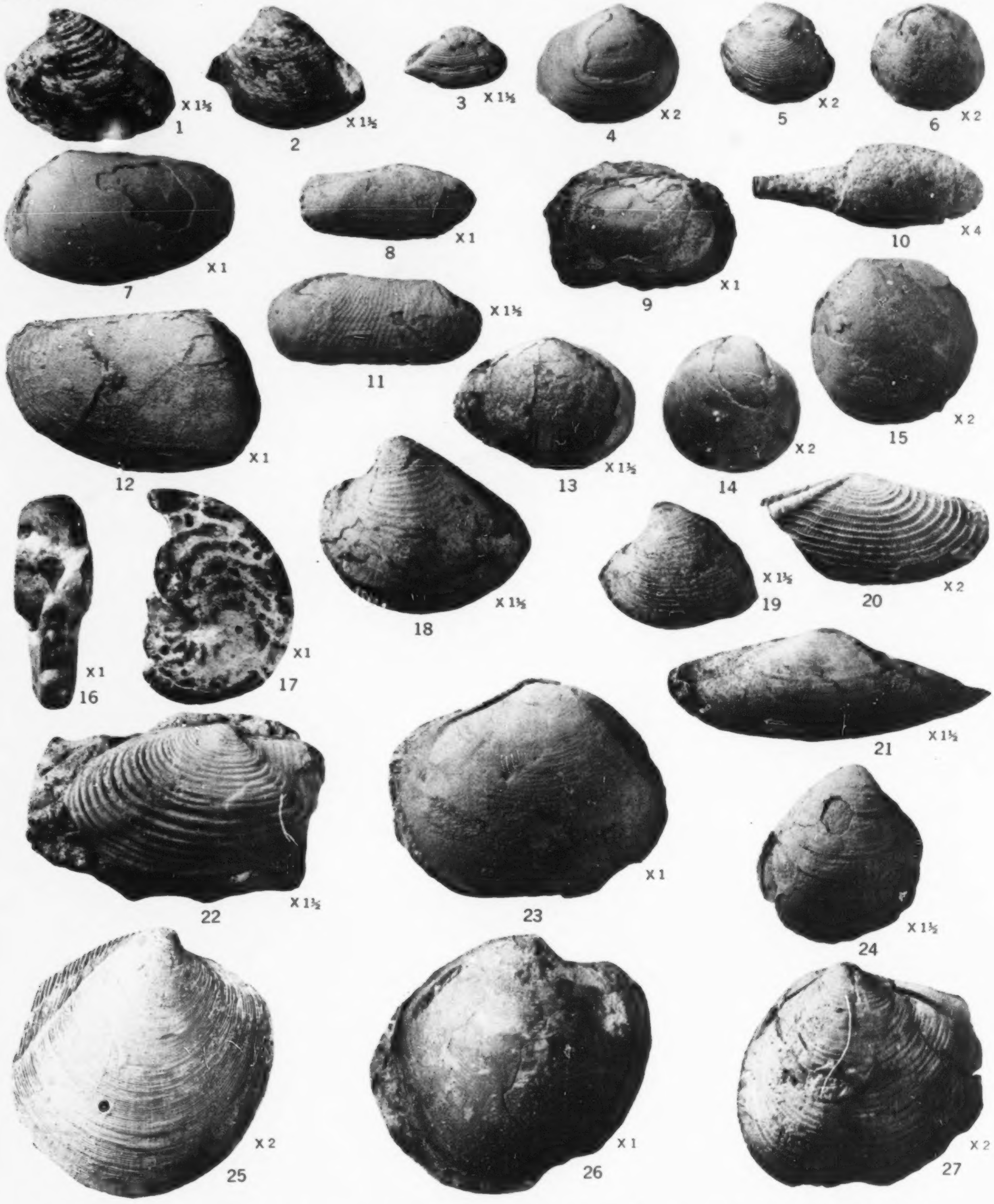
LATE EOCENE MOLLUSKS FROM MARINE ROCKS AND LATE OLIGOCENE MOLLUSKS FROM BOHIO FORMATION (FIGS. 15, 16, 19, 20, 21)

PLATE 91

FIGURES 1, 2. *Anomalocardia heothina* Woodring, n. sp. (p. 707).
1. Paratype, left valve. Length 21 mm. Locality 42i. USNM 647741.
2. Type, left valve. Length 19.8 mm. Locality 42i. USNM 647740.
3. *Caryocorbula platys* Woodring, n. sp. (p. 711).
Type, right valve. Length 12.6 mm. Locality 42f. USNM 647750.
4. *Pleiorytis orthra* Woodring, n. sp. (p. 710).
Type, right valve. Length 13.8. Locality 42d. USNM 647746.
5, 6. *Myrtaea* (*Myrtaea*) *enischna* Woodring, n. sp. (p. 621).
5. Paratype, left valve. Length (incomplete) 10.8 mm. Locality 54h. USNM 647338.
6. Type, left valve. Length 10.2 mm. Locality 54h. USNM 647337.
7, 12. *Gari* (*Gobraeus*) *listrota hadratera* Woodring, n. subsp. (p. 672).
7. Type, right valve. Length 41.3 mm. Locality 42d. USNM 647602.
12. Paratype, left valve. Length 47 mm. Locality 42d. USNM 647603.
8. *Tagelus* (*Tagelus*) *orthrius* Woodring, n. sp. (p. 674).
Type, right valve. Length 30.5 mm. Locality 42f. USNM 647608.
9. *Macrocallista* (*Paradione*) *maculata* (Linné), small form (p. 689).
Right valve. Length 26 mm. Locality 42d. USNM 647696.
10. *Cardiomya* sp. (p. 723).
Right valve. Length 9.8 mm. Locality 54m. USNM 647805.
11. *Solecurtus vicksburgensis* (Aldrich) (p. 673).
Left valve. Length 26.4 mm. Locality 42d. USNM 647605.
13. *Tellina* (*Merisca*?) *pycna* Woodring, n. sp. (p. 658).
Type, right valve. Length 22 mm. Locality 42f. USNM 647542.
14, 15. *Diplodonta* (*Diplodonta*) cf. *D. alta* Dall (p. 625).
14. Left valve. Length 12.8 mm. Locality 42d. USNM 647361.
15. Right valve. Length 15.5 mm. Locality 42f. USNM 647360.
16, 17. *Aturia* sp. (p. 725).
Two views of small specimen. Greatest preserved diameter 37 mm, greatest thickness 14.3 mm. Locality 42d. USNM 647809.
18, 19. *Chione* (*Chionopsis*) cf. *C.* (*C.*) *posorjensis* Olsson (p. 701).
18. Left valve. Length 24.4 mm. Locality 42g. USNM 647723.
19. Left valve. Length 18.3 mm. Locality 42g. USNM 647724.
20, 21. *Tellina* (*Tellinella*) *protera* Woodring, n. sp. (p. 656).
20. Paratype, immature right valve. Length (incomplete) 21 mm. Locality 42d. USNM 647536.
21. Type, left valve, internal mold. Length (practically complete) 38.5 mm. Locality 42d. USNM 647535.
22. *Cyathodonta*? *dolicha* Woodring, n. sp. (p. 721).
Type, left valve. Length (incomplete) 30 mm. Locality 42d. USNM 647801.
23. *Semele* cf. *S. venusta* (Reeve) (p. 676).
Length, left internal mold, 51 mm. Locality 42d. USNM 647611.
24. *Polymesoda* cf. *P. aequilatera* (Deshayes) (p. 679).
Right valve. Length 20.7 mm. Locality 42f. USNM 647625.
25. *Miltha* sp. (p. 619).
Right valve. Length 23 mm. Locality 42d. USNM 647312.
26. *Dosinia* (*Dosinia*) aff. *D. delicatissima* Brown and Pilsbry (p. 694).
Right valve. Length 45.7 mm. Locality 42d. USNM 647702.
27. *Raeta* cf. *R. gardnerae* (Spieker) (p. 653).
Small left valve. Length (incomplete) 23.7 mm. Locality 42i. USNM 647520.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26
X 2
27

LATE OLIGOCENE MOLLUSKS FROM BOHIO AND CAIMITO (FIGS. 5, 6, 10) FORMATIONS

PLATE 92

FIGURE 1. *Pitar* (*Pitar*?) *dinotus* Woodring, n. sp. (p. 685).
Type, left valve of internal mold of articulated specimen. Length (practically complete) 31.8 mm. Locality 62. USNM 647651.

2. *Tellina* (*Eurytellina*) *ophiaca* Woodring, n. sp. (p. 663).
Type, right valve of internal mold of articulated specimen. Length 27 mm. Locality 112a. USNM 647575.

3. *Lucina* (*Lepilucina*) aff. *L. gratis* Olsson (p. 615).
Left valve. Length 31.8 mm. Locality 106. USNM 647384.

4, 8. *Psammacoma diphas* Woodring, n. sp. (p. 667).
4. Paratype, right valve of internal mold of articulated specimen. Length 42.9 mm. Locality 110. USNM 647588.
8. Type, left valve of internal mold of articulated specimen. Length (incomplete) 47.7 mm. Locality 111b. USNM 647587.

5. *Tellina* (*Eurytellina*) *punicea* Born (p. 661).
Left valve. Length 36 mm. Locality 54k. USNM 647548.

6, 7. *Pegophysema* cf. *P. mauryae* (Pilsbry and Johnson) (p. 622).
Left valve and umbonal view of articulated specimen. Length 43 mm. Locality 56. USNM 647354.

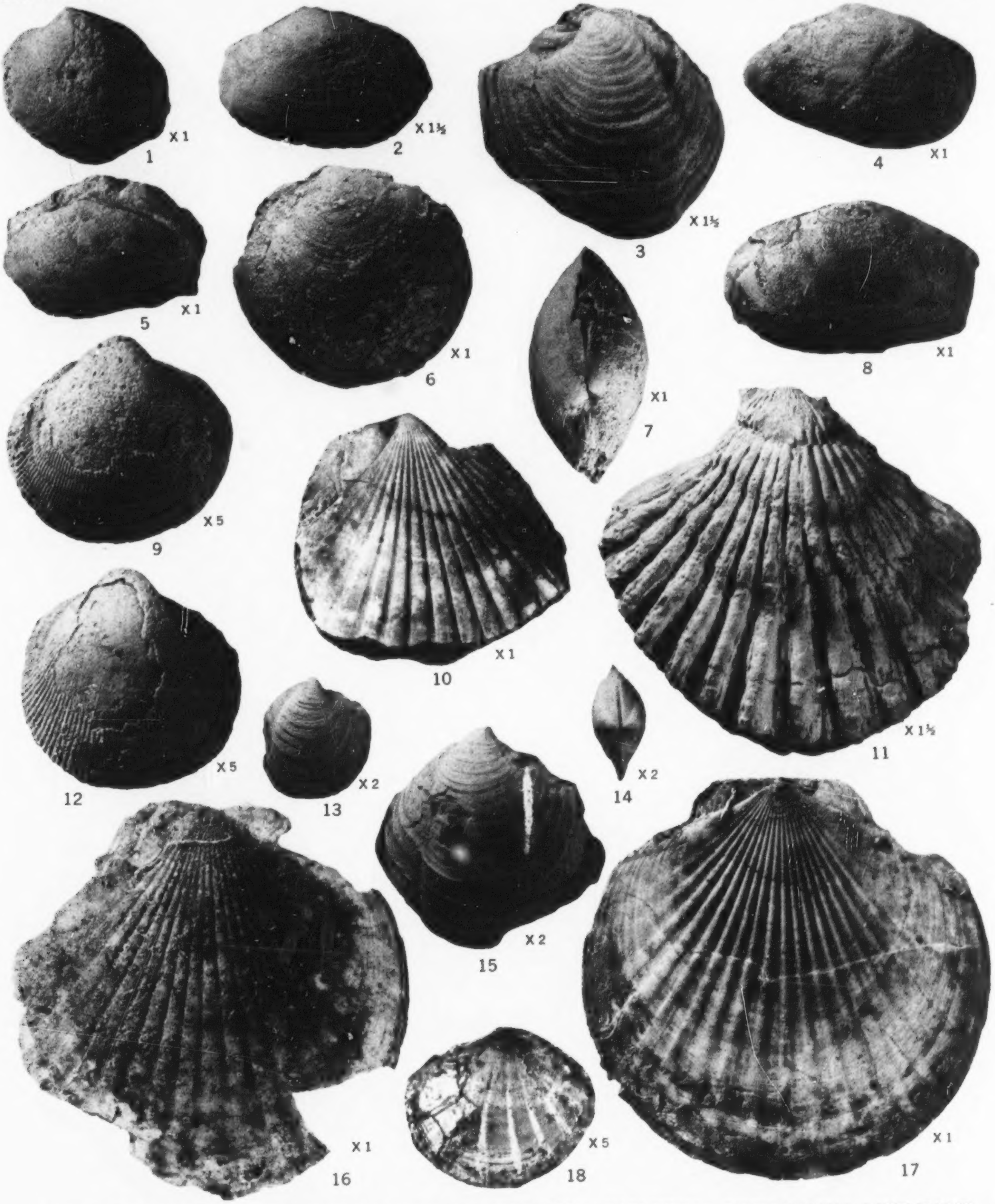
9, 12. *Microcardium pollostum* Woodring, n. sp. (p. 645).
9. Paratype, left valve. Length 8.8 mm. Locality 54k. USNM 647505.
12. Type, left valve. Length 8.5 mm. Locality 54k. USNM 647504.

10, 16, 17. *Flabellipecten gatunensis protistus* Woodring, n. subsp. (p. 583).
10. Paratype, thick-shelled right valve. Length (incomplete) 46 mm. Locality 56. USNM 646976.
16. Type, thin-shelled right valve. Length (almost complete) 71 mm. Locality 56. USNM 646974.
17. Paratype, thin-shelled left valve. Length 72.3 mm. Locality 56. USNM 646975.

11. *Nodipecten denaius*? Woodring, n. sp. (p. 598).
Right valve. Length 47 mm. Locality 52a. USNM 647209.

13–15. *Phacoides cerma* Woodring, n. sp. (p. 614).
13, 14. Right valve and umbonal view of immature articulated specimen. Length 11 mm. Locality 54h. USNM 647317.
15. Type, right valve. Length (not quite complete) 20 mm. Locality 54h. USNM 647316.

18. *Propeamussium* cf. *P. pennyi* (Harris) (p. 577).
Right valve. Length 7 mm. Locality 55a. USNM 647812.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13 X2
14 X2
15 X2
16 X1
17 X1
18 X5

LATE OLIGOCENE MOLLUSKS FROM CAIMITO FORMATION, INCLUDING QUEBRANCHA LIMESTONE MEMBER (FIG.1), AND EARLY MIOCENE MOLLUSKS FROM CULEBRA FORMATION (FIGS. 2–4, 8)

PLATE 93

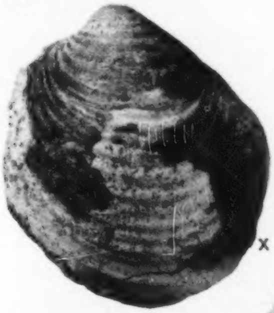
FIGURES 1, 8. *Clementia (Clementia) dariena rabelli* Maury (p. 698).
  1. Left valve of articulated specimen. Length 39.7 mm. Locality 108a. USNM 647716.
  8. Right valve of articulated specimen. Length 27.9 mm. Locality 111b. USNM 647717.

2, 4. *Trinitasia* aff. *T. sanctiandreae* (Maury (p. 651).
  2. Elongate left valve. Length 48 mm. Locality 108c. USNM 647621.
  4. Short left valve. Length (practically complete) 38.5 mm. Locality 108c. USNM 647620.

3. *Bothrocorbula (Hexacorbula) cruziana* (Olsson) (p. 713).
  Right valve. Length 10.3 mm. Locality 111b. USNM 647757.

5. *Kuphus "incrassatus* Gabb" (p. 719).
  Length 62 mm, diameter of anterior end 13.4 mm, diameter of posterior end 6.5 mm. Locality 112a. USNM 647796.

6, 7, 9–11. *Crassostrea cahobasensis* (Pilsbry and Brown) (p. 610).
  6, 7. Left valve. Length 82 mm. Locality 104, USNM 647289.
  9, 11. Right valve. Length 60 mm. Locality 103. USNM 647288.
  10. Right valve. Length 55 mm. Locality 104b. USNM 647287.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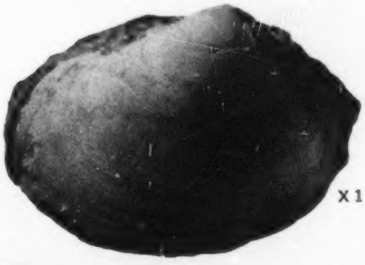
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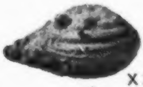
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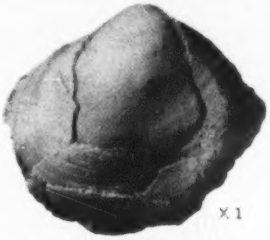
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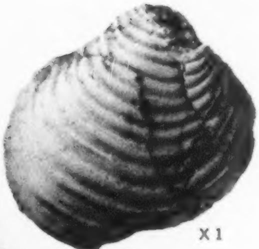
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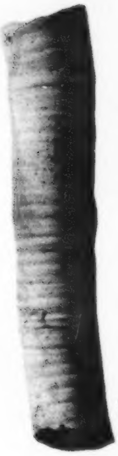
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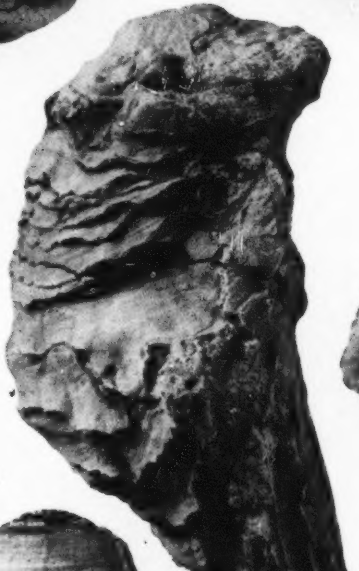
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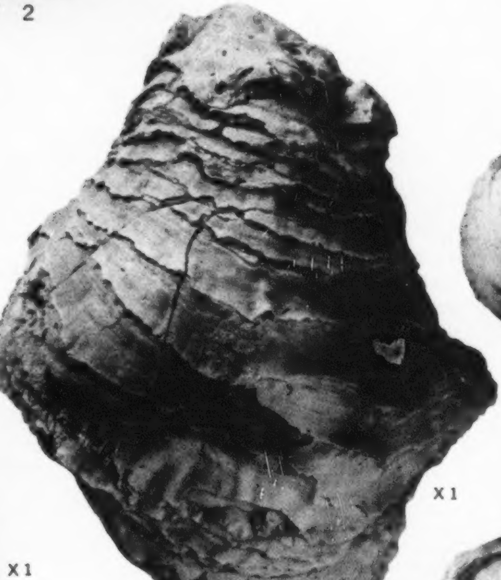
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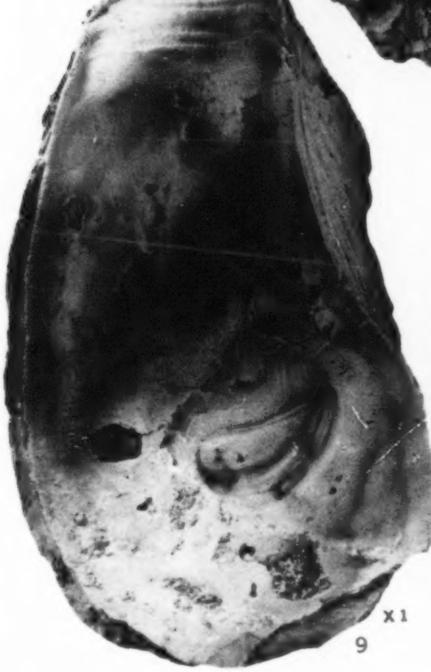
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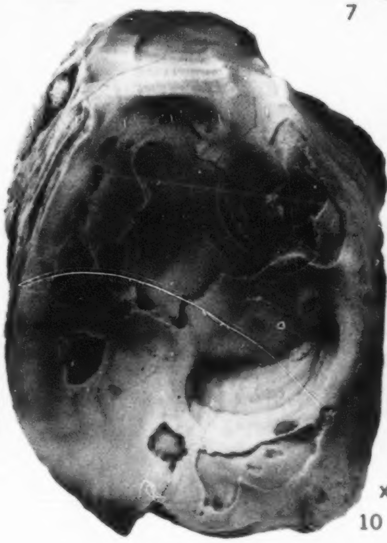
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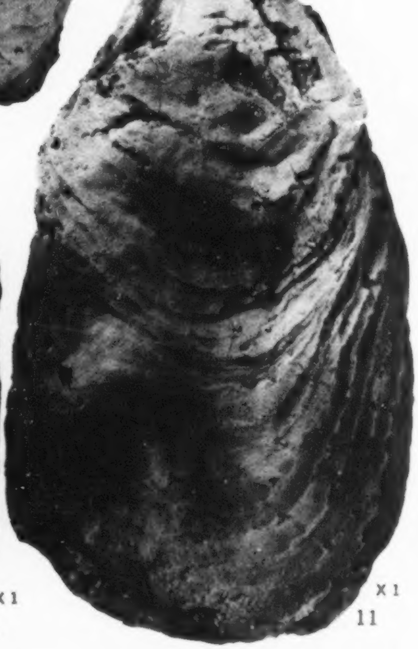
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11

EARLY MIOCENE MOLLUSKS FROM CULEBRA FORMATION

PLATE 94

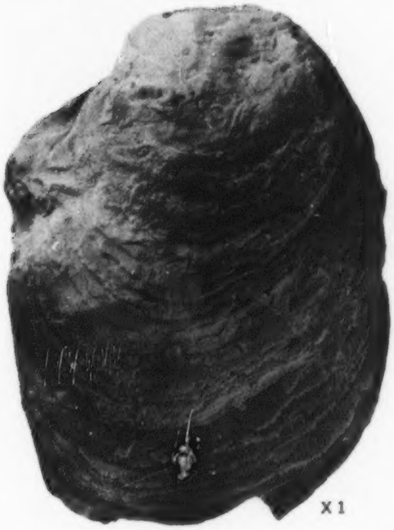
FIGURES 1, 3, 5. *Crassostrea cahobasensis* (Pilsbry and Brown) (p. 610).
- 1. Right valve. Length 55 mm. Locality 104b. USNM 647287.
- 3. Chomata-bearing left valve. Length 53 mm. Locality 104a. USNM 647290.
- 5. Chomata-bearing right valve. Length 47 mm. Locality 104b. USNM 647291.

2. *Cyclopecten* sp. b. (p. 576).
Right valve. Length 14.5 mm. Locality 127a. USNM 647212.

4. *Gryphaeostrea* sp. (p. 610).
Right valve. Length 9.8 mm. Locality 101h. USNM 647297.

6. *Chlamys anguillensis* (Guppy) (p. 589).
Right valve. Length 22.4 mm. Locality 119. USNM 647213.

7, 8. "*Hyotissa*" *tryoni* (Gabb) (p. 607).
Exterior (fig. 7) and interior (fig. 8) of left valve. Length 88.5 mm. Locality 116a. USNM 647278.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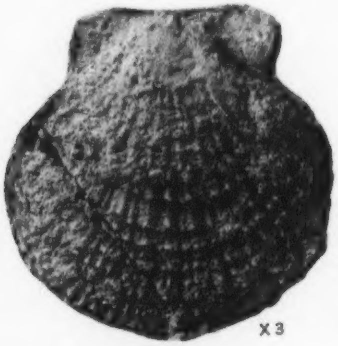
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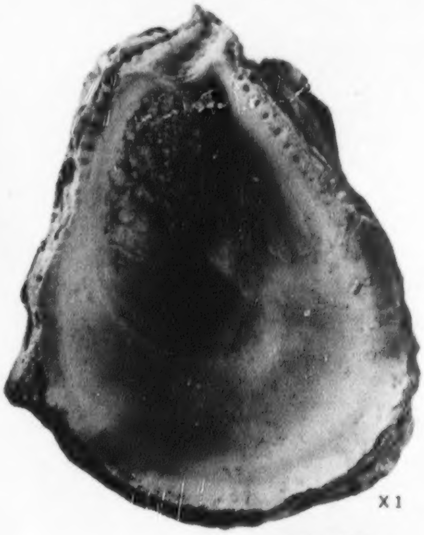
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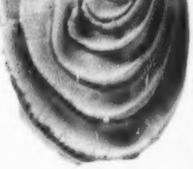
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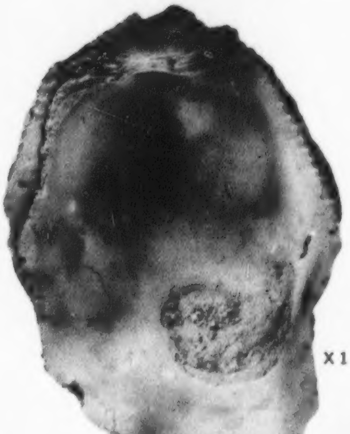
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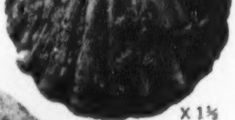
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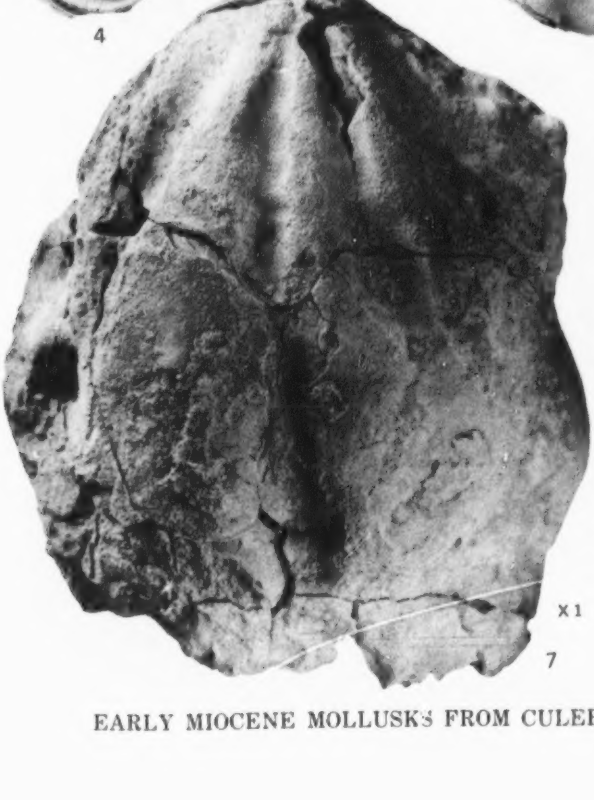
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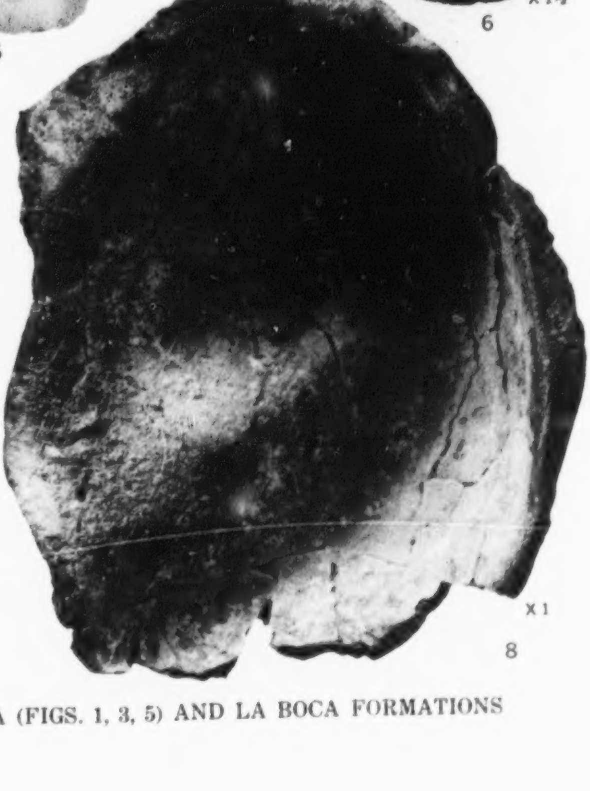
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8

EARLY MIOCENE MOLLUSKS FROM CULEBRA (FIGS. 1, 3, 5) AND LA BOCA FORMATIONS

PLATE 95

FIGURES 1, 2, 4, 7, 12. *Dimya adaia* Woodring, n. sp. (p. 602).

1, 7. Type, right valve, interior (fig. 1) and exterior (fig. 7). Length 18.6 mm. Locality 101h. USNM 647201.

2. Right valve, showing strong radial sculpture. Length 16.5 mm. Locality 101h USNM 647263.

4. Left valve. Length 17 mm. Locality 101h. 647204.

12. Paratype, left valve. Length 17 mm. Locality 101h. USNM 647202.

3, 5, 8, 11. *Cubitostrea rugifera* (Dall) (p. 613).

3, 5. Interior (fig. 3) and exterior (fig. 5) of immature right valve. Length 17.4 mm. Locality 101h. USNM 647302.

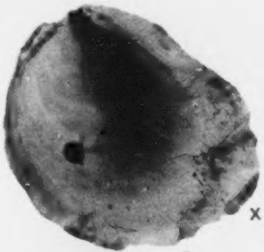
8, 11. Interior (fig. 8) and exterior (fig. 11) of somewhat warped right valve. Length 47.2 mm. Locality 101a. USNM 647301.

6, 9. *Hadralucina xenica* Woodring, n. sp. (p. 623).

Type, articulated specimen, ventral view (fig. 6) and right valve (fig. 9). Length 115 mm. Locality 101j. USNM 647624.

10. *Pegophysema* cf. *P. mauryae* (Pilsbry and Johnson) (p. 622).

Right valve of internal mold of articulated specimen. Length 42.5 mm. Locality 127. USNM 647355.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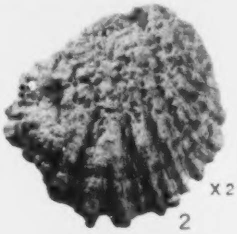
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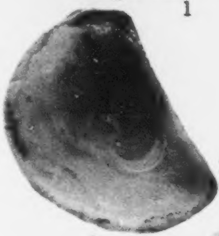
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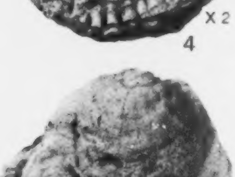
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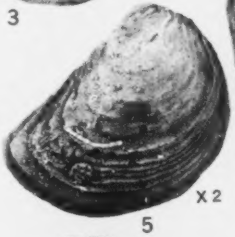
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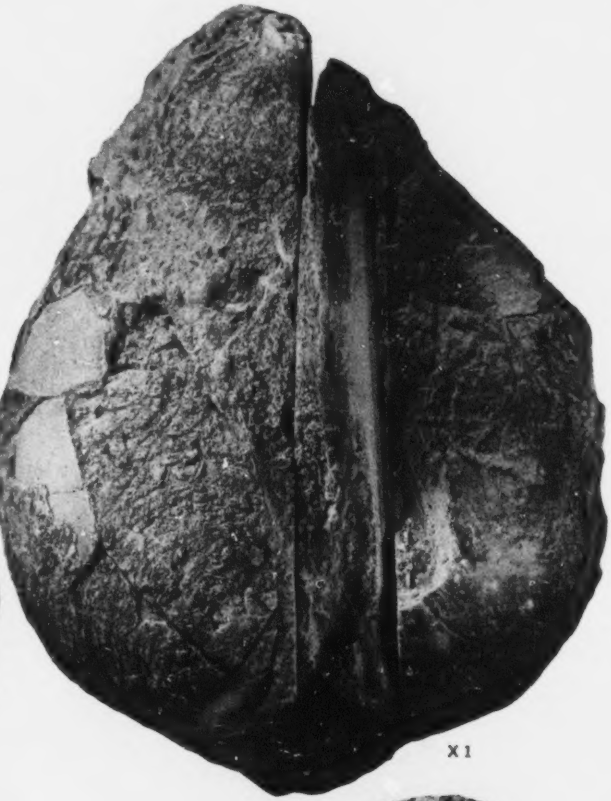
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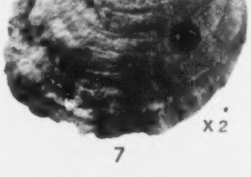
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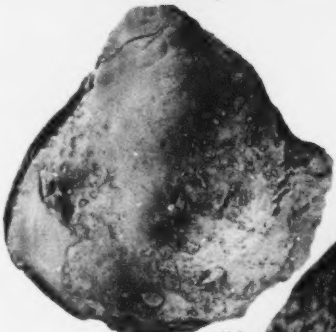
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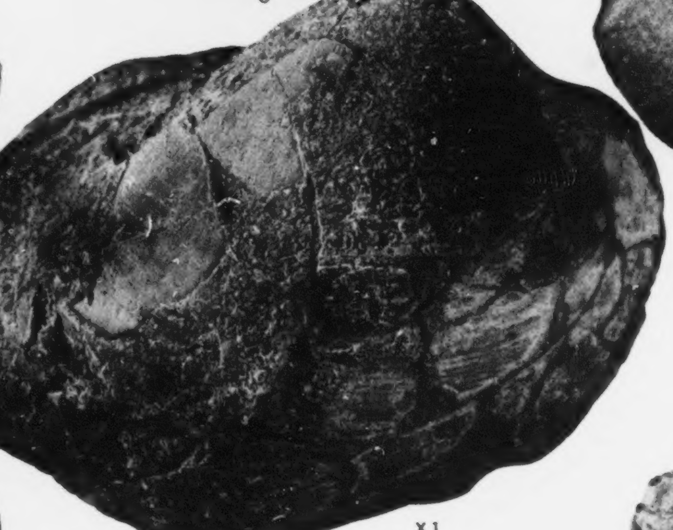
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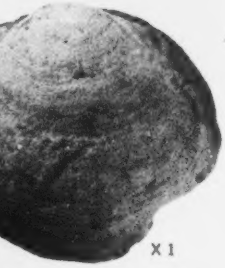
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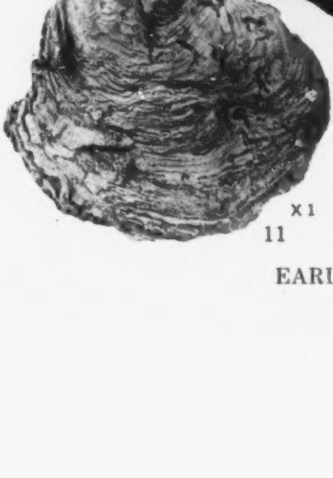
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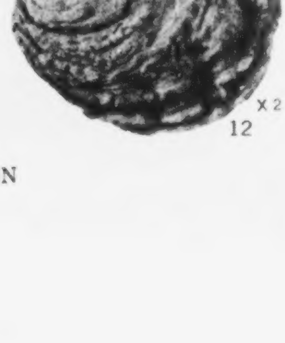
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12

EARLY MIOCENE MOLLUSKS FROM LA BOCA FORMATION

PLATE 96

FIGURES 1–3. *Flabellipecten antiguensis* (Brown) (p. 585).

1, 2. Left valve (fig. 1) and right valve (fig. 2) of articulated specimen. Length (practically complete) 54 mm. Locality 99f. USNM 647190.

3. Interior of large imperfect left valve. Length (incomplete) 60 mm. Locality 99f. USNM 647191.

4. Unionidae? genus? (p. 614).

Umbonal view of internal molds of articulated valves, unhinged and spread apart. Length (incomplete) 33.5 mm. Locality 122c. USNM 647373.

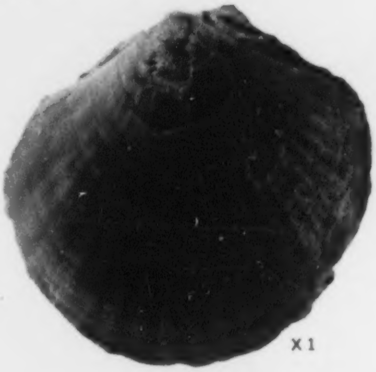
5, 7, 8. *Amusium toulae* (Brown and Pilsbry) (p. 588).

5. Left valve of articulated specimen. Length (almost complete) 79 mm. Locality 101f. USNM 647193.

7, 8. Right (fig. 7) and left (fig. 8) valves of articulated specimen. Length 78.3 mm. Locality 101h. USNM 647194.

6. *Cyclopecten* sp. a (p. 576).

Right valve. Length 13.7 mm. Locality 99g. USNM 647211.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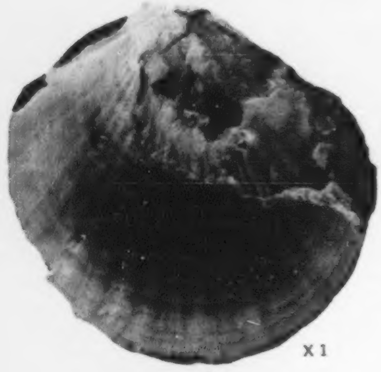
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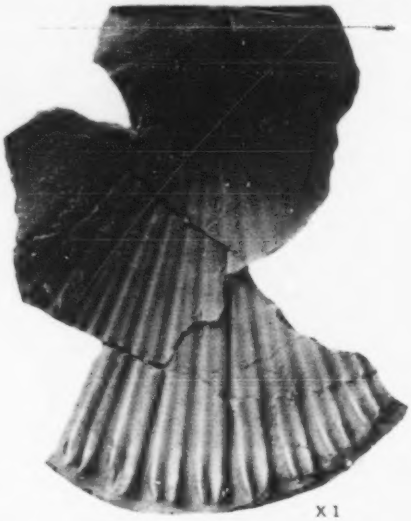
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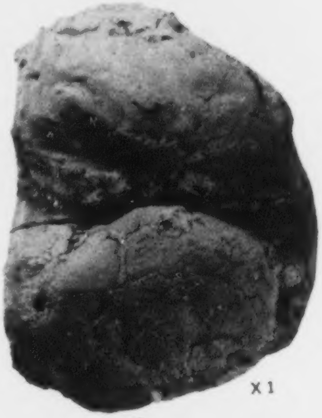
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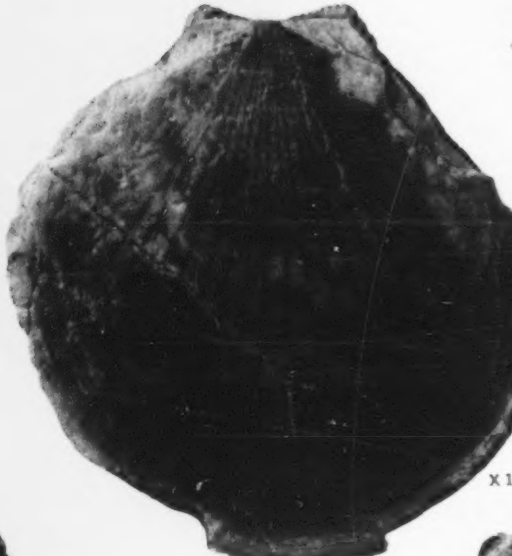
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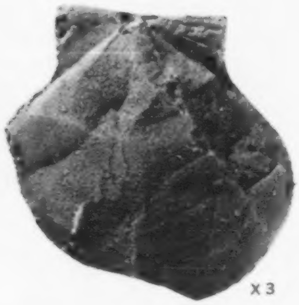
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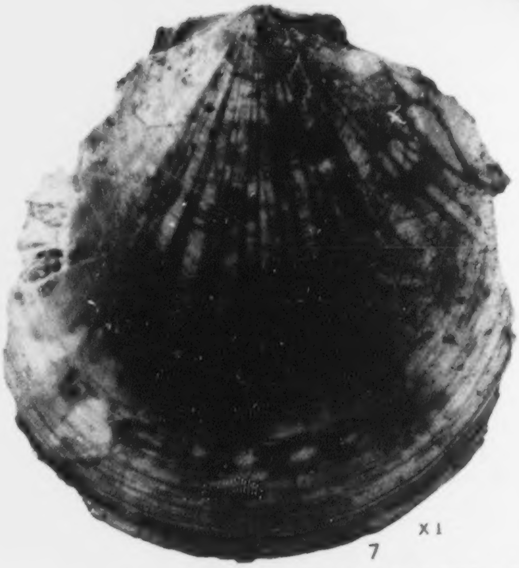
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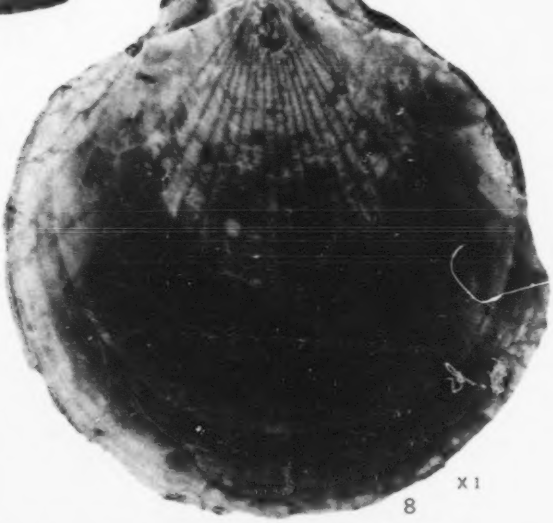
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8

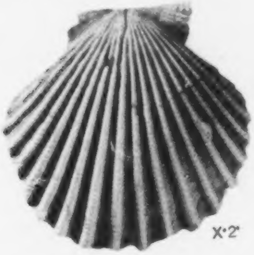
EARLY MIOCENE MOLLUSKS FROM LA BOCA FORMATION AND EARLY MIOCENE FRESH-WATER MUSSEL FROM CUCARACHA FORMATION (FIG. 4)

PLATE 97

FIGURES 1–3, 6. *Lepidopecten proterus* Woodring, n. sp. (p. 593).
1. Paratype, right valve. Length (practically complete) 18.5 mm. Locality 101h. USNM 647123.
2. Left valve, showing strong concentric sculpture. Length 16.9 mm. Locality 101h. USNM 647124.
3. Exceptional right valve, showing some of sculptural features of left valve. Length 17 mm. Locality 101h. USNM 647125.
6. Type, left valve. Length 22.6 mm. Locality 101h. USNM 647122.

4, 7. *Aequipecten canalis* (Brown and Pilsbry) (p. 591).
4. Left valve of articulated specimen. Length 33.3 mm. Locality 101h. USNM 647215.
7. Right valve of articulated specimen. Length 40.8 mm. Locality 99f. USNM 647214.

5, 8–10. *Spondylus scotti* Brown and Pilsbry (p. 601).
5, 9. Right (fig. 5) and left (fig. 9) valves of narrow articulated specimen. Length 52.8 mm. Locality 99. USNM 647243.
8, 10. Right (fig. 8) and left (fig. 10) valves of wide articulated specimen. Length 67 mm. Locality 101e. USNM 647244.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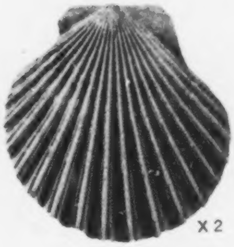
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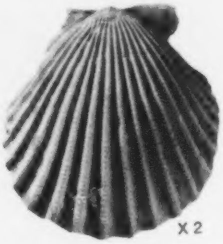
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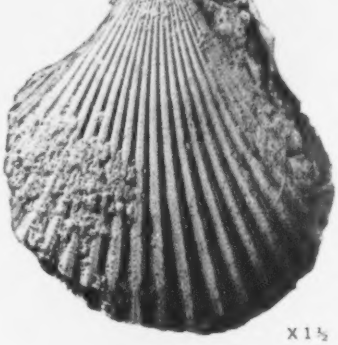
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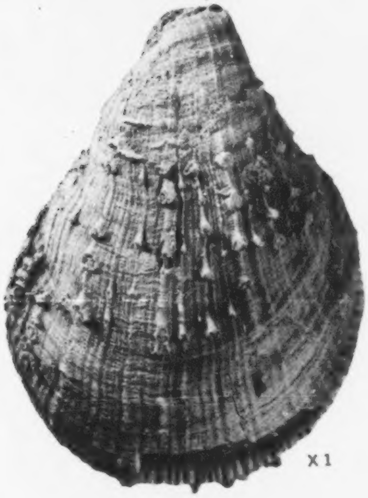
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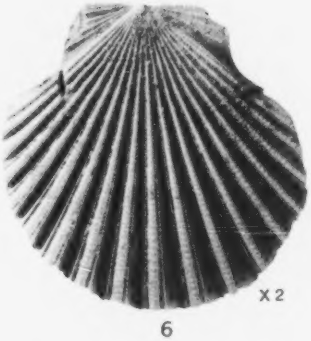
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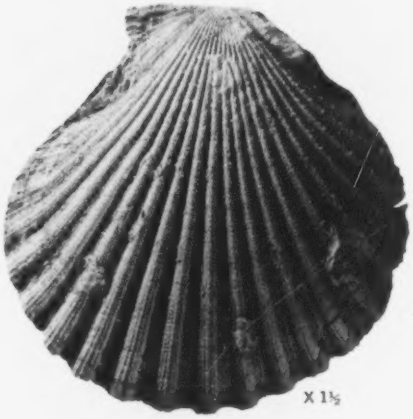
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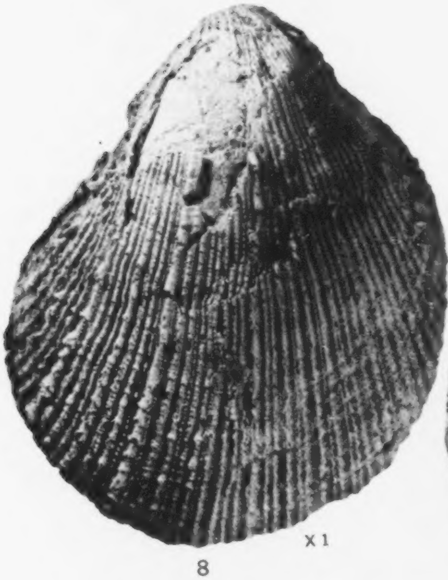
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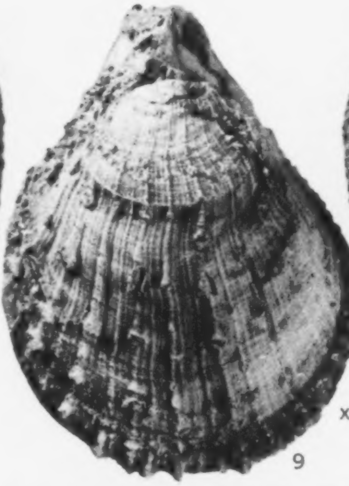
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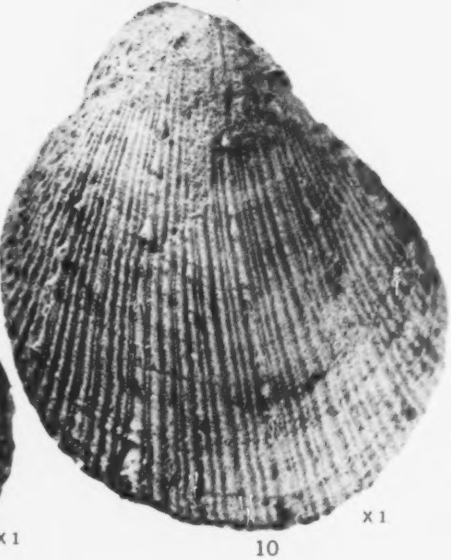
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10

EARLY MIOCENE MOLLUSKS FROM LA BOCA FORMATION

PLATE 98

FIGURE 1. *Trachycardium* (*Trachycardium*) cf. *T.* (*T.*) *isocardia* Linné (p. 637).
Left valve. Length 52 mm. Locality 99f. USNM 647471.

2. *Hyotissa haitensis* (Sowerby) (p. 607).
Left valve of articulated specimen. Length 62.5 mm. Locality 101h. USNM 647296.

3. *Lirophora* (*Lirophora*) cf. *L.* (*L.*) *quirosensis* (H. K. Hodson) (p. 703).
Left valve. Length 30 mm. Locality 119. USNM 647731.

4, 8. *Trachycardium* (*Dallocardia*) *phlyctaena* (Dall) (p. 637).
4. Right valve. Length 28 mm. Locality 116a. USNM 647436.
8. Left valve. Length (incomplete) 33.8 mm. Locality 115a. USNM 647435.

5. *Trigoniocardia* (*Apiocardia*) cf. *T.* (*A.*) *simrothi* (Dall) (p. 643).
Left valve. Length (incomplete) 10.7 mm. Locality 114. USNM 647480.

6. *Varicorbula* cf. *V. vieta* (Guppy) (p. 715).
Right valve. Length 7.6 mm. Locality 101i. USNM 647763.

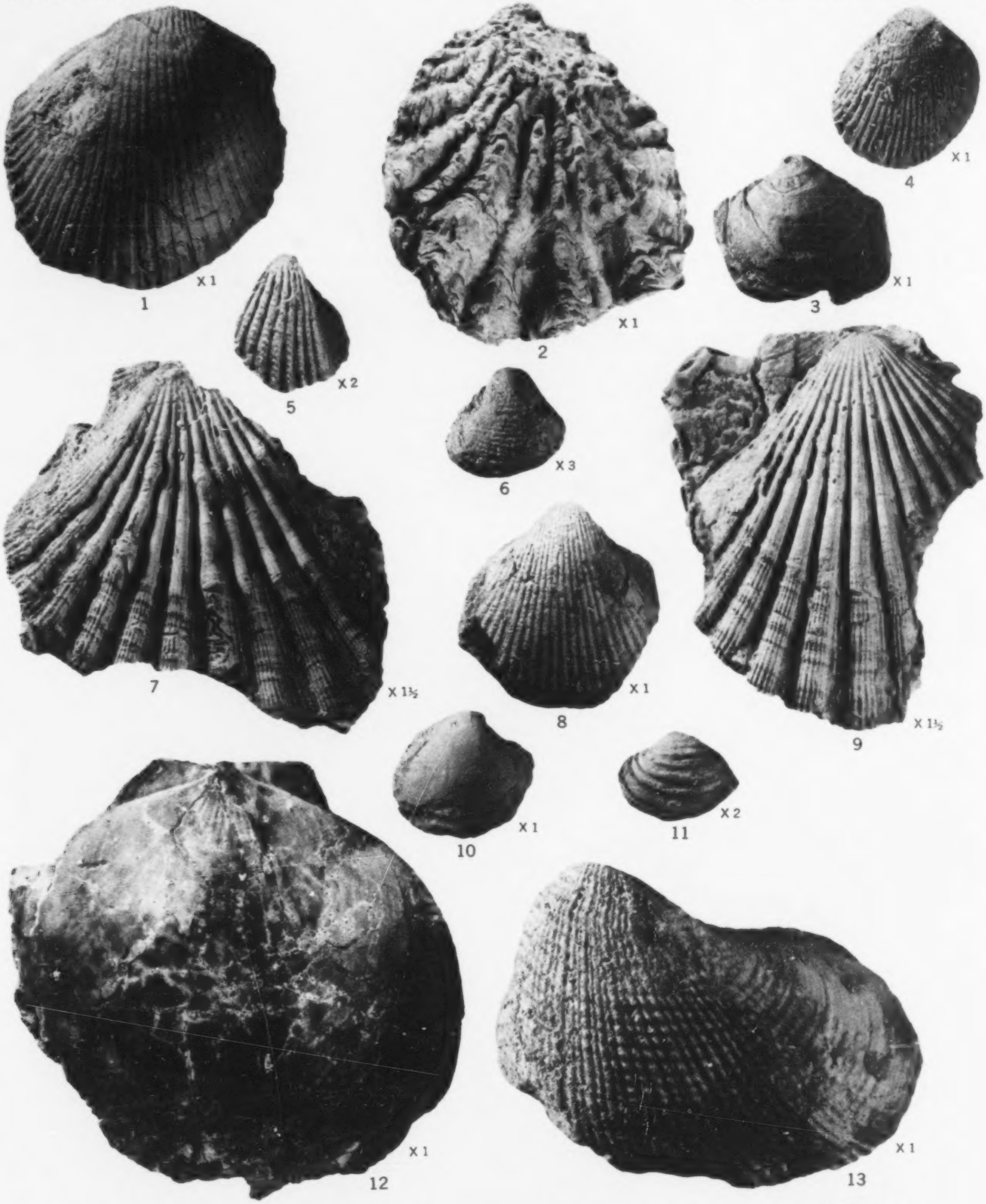
7, 9. *Nodipecten denaius* Woodring, n. sp. (p. 598).
Type, right (fig. 7) and left (fig. 9) valves of articulated specimen. Length (almost complete) 47.5 mm. Locality 101g. USNM 647126.

10. *Pitar* (*Pitar*) aff. *P. quirosanus* (H. K. Hodson) (p. 685).
Right valve of internal mold of articulated specimen. Length 26.5 mm. Locality 99d. USNM 647652.

11. *Bothrocorbula* (*Hexacorbula*) *cruziana* (Olsson) (p. 713).
Left valve. Length 11mm. Locality 116a. USNM 647758.

12. *Amusium sol* (Brown and Pilsbry) (p. 587).
Left valve, topotype. Length (almost complete) 80.5 mm. Locality 119a. USNM 647192.

13. *Pholadomya* cf. *P. walli* Maury (p. 720).
Left valve of internal mold of articulated specimen. Length (almost complete) 77.2 mm. Locality 111. USNM 647797.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13

EARLY MIOCENE MOLLUSKS FROM CULEBRA (FIG. 13) AND LA BOCA FORMATIONS

PLATE 99

FIGURES 1, 6. *Eucrassatella (Eucrassatella) mediamericana* (Brown and Pilsbry) (p. 633).
1. Right valve. Length 34.2 mm. Locality 101h. USNM 647422.
6. Right valve. Length about 46 mm. Locality 101h. USNM 647421.

2, 3. *Trachycardium (Dallocardia) dominicense dominicense* (Gabb), small form (p. 638).
2. Left valve. Length, reduced by lateral crushing 32.6 mm. Locality 101h. USNM 647457.
3. Left valve. Length 37.8 mm. Locality 99f. USNM 647456.

4, 5. *Tellina (Eurytellina) vetula* Brown and Pilsbry (p. 664).
4. Immature carinate right valve. Length 21.6 mm. Locality 99e. USNM 647577.
5. Left valve. Length 40.5 mm. Locality 116a. USNM 647576.

7, 11. *Nemocardium hadraterum* Woodring, n. sp. (p. 644).
7. Type, internal mold of right valve. Length (almost complete) 38.8 mm. Locality 119b. USNM 647485.
11. Paratype, right valve of internal mold of articulated small specimen. Length 25 mm. Locality 101h. USNM 647487.

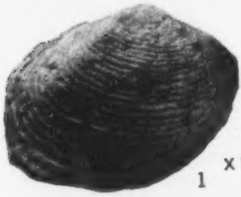
8, 9. *Donax* aff. *D. asper* Hanley (p. 671).
Posterior end (fig. 8) and side view (fig. 9) of right valve. Length (practically complete) 25 mm. Locality 116a, USNM 647598.

10, 13, 14. *Donax gonioides* Woodring, n. sp. (p. 671).
10. Type, right valve. Length 24 mm. Locality 116a. USNM 647596.
13, 14. Paratype, left valve, posterior end (fig. 13) and side view (fig. 14). Length 24.5 mm. Locality 116a. USNM 647597.

12. *Clementia (Clementia) dariena dariena* (Conrad) (p. 699).
Right valve of articulated specimen. Length 51.7 mm. Locality 101h. USNM 647718.

15, 19. *Venericardia (Glyptoactis) metaicha* Woodring, n. sp. (p. 628).
15. Paratype, right valve. Length (incomplete) 30.7 mm. Locality 116a. USNM 647379.
19. Type, right valve. Length 32 mm. Locality 116a. USNM 647378.

16–18. *Chama strepta* Woodring, n. sp. (p. 629).
Type, left valve. Length 39.5 mm. Locality 115a. USNM 647410.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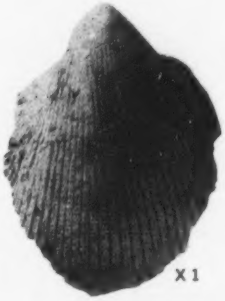
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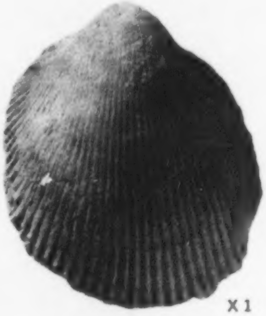
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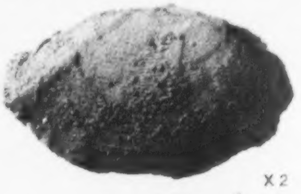
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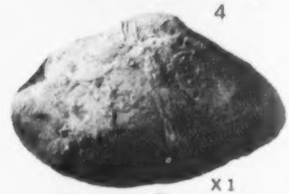
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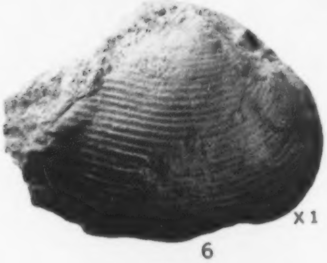
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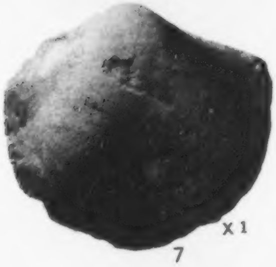
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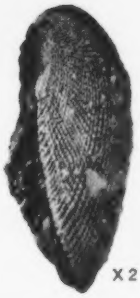
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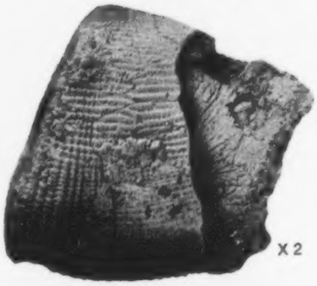
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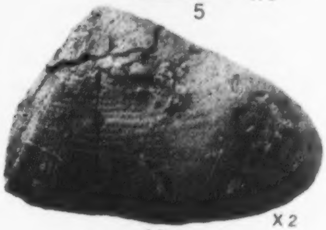
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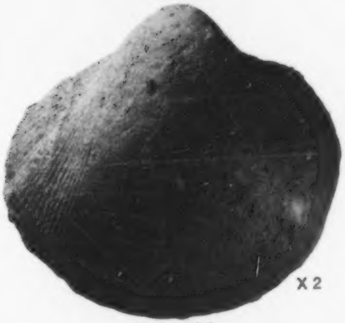
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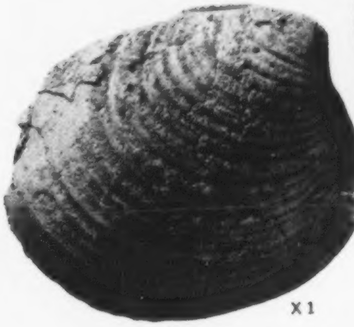
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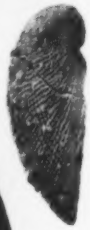
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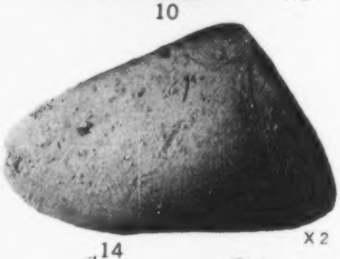
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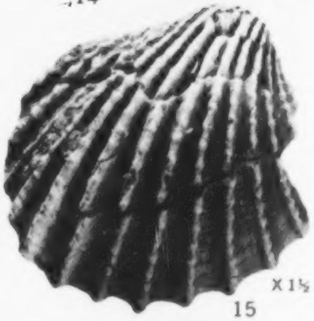
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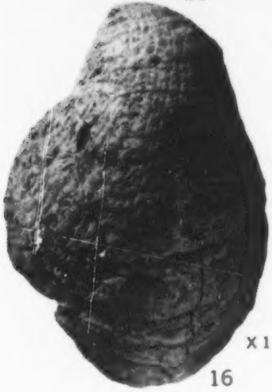
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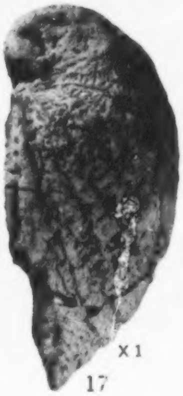
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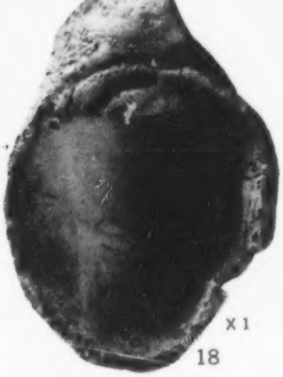
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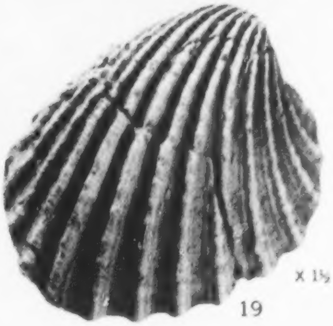
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EARLY MIOCENE MOLLUSKS FROM LA BOCA FORMATION

PLATE 100

FIGURE 1. *Chione* (*Chionopsis*) *propinqua* Spieker (p. 701).
Right valve. Length 26.6 mm. Locality 116a. USNM 647726.

2, 3, 6. *Ventricolaria harrisiana* (Olsson) (p. 681).
2. Right valve. Length 31.3 mm. Locality 101e. USNM 647637.
3. Left valve. Length 33 mm. Locality 99d. USNM 647639.
6. Right valve. Length 35.9 mm. Locality 99f. USNM 647638.

4, 7. *Venericardia* (*Glyptoactis*) *stenygra* Woodring, n. sp. (p. 628).
Right valve (fig. 4) and umbonal view (fig. 7) of articulated specimen. Length (almost complete) 34.6 mm. Locality 118b. USNM 647380.

5. *Chlamys* sp. (p. 590).
Left? valve. Length (practically complete) 26 mm. Locality 118a. USNM 647217.

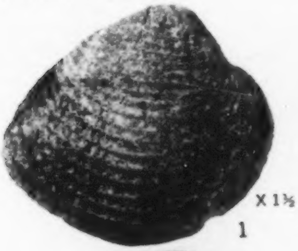
8. *Psammacoma diphas* Woodring, n. sp. (p. 667).
Left valve. Length 39.5. Locality 101i. USNM 647589.

9. *Chlamys sentis* (Reeve)? (p. 590).
Right valve. Length (practically complete) 26.2 mm. Locality 117a. USNM 647216.

10. *Amusium toulae* (Brown and Pilsbry) (p. 588).
Left valve of articulated specimen showing relatively strong, fine lamination. Length (incomplete) 73.5 mm. Locality 101h. USNM 647195.

11. *Pitar* (*Pitar*) cf. *P. coroanus* (H. K. Hodson) (p. 686).
Left internal mold. Length 37.7 mm. Locality 85. USNM 647653.

12, 13. *Hyotissa polylopha* Woodring, n. sp. (p. 607).
Type, left (fig. 12) and right (fig. 13) valves of articulated specimen. Length 84.5 mm. Locality 117c. USNM 647280.



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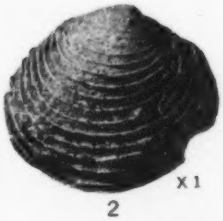

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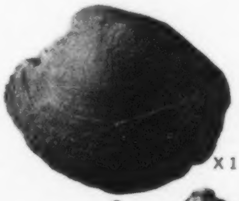

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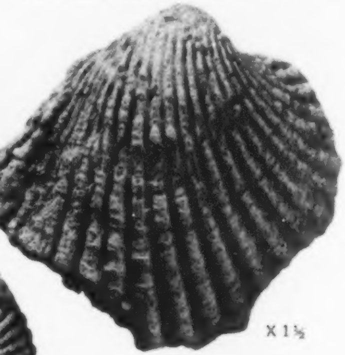

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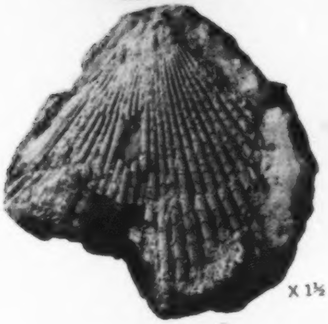

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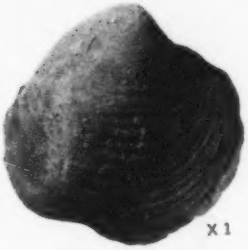

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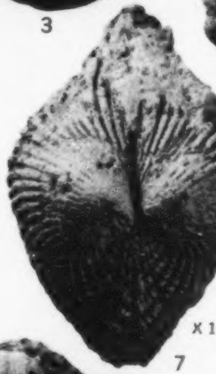

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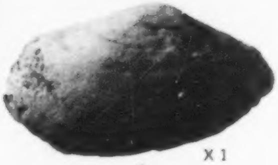

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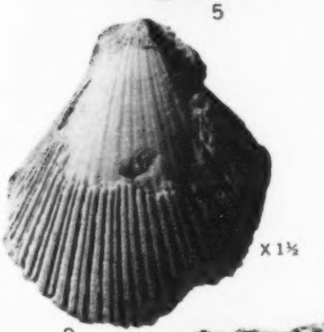

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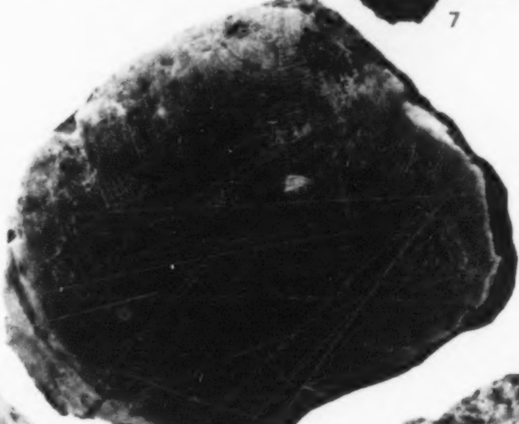

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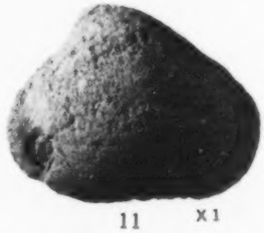

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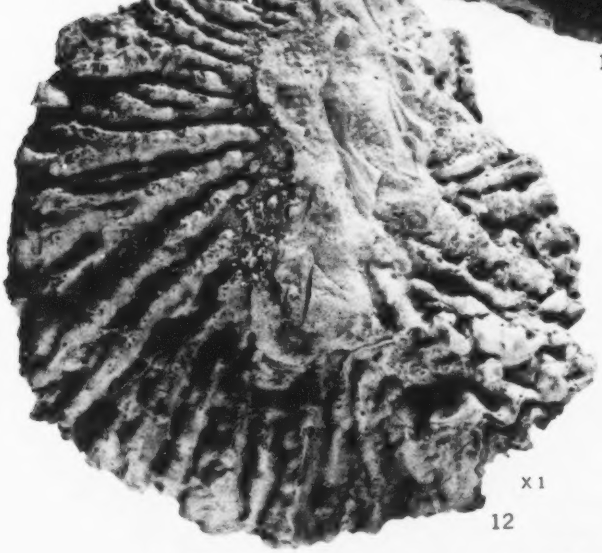

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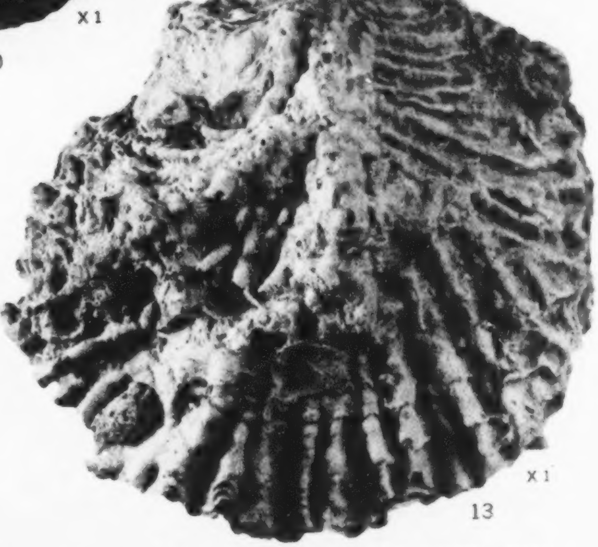

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EARLY MIOCENE MOLLUSKS FROM LA BOCA FORMATION AND ITS EMPERADOR LIMESTONE MEMBER, AND UPPER MEMBER OF ALHAJUELA FORMATION (FIG. 11)

PLATE 101

FIGURE 1. *Panopea* sp. (p. 717).
Right valve, internal mold. Length 107 mm. Locality 79. USNM 647793.

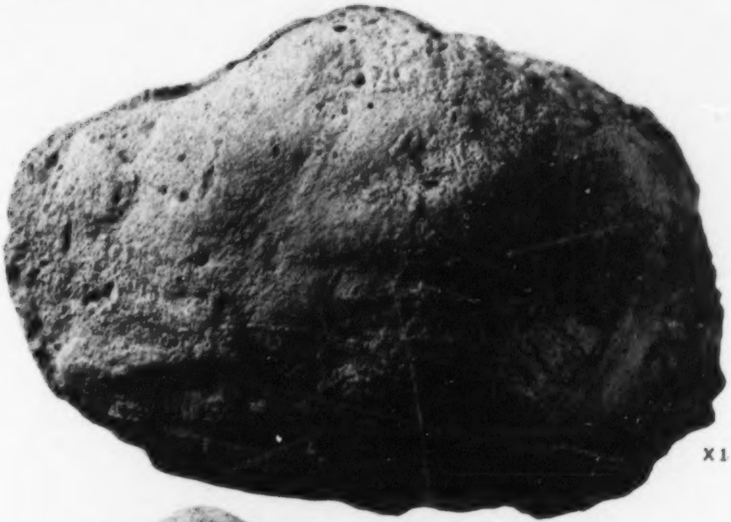
2. *Psammacoma talaor* Woodring, n. sp. (p. 669).
Type, left valve. Length 53.2 mm. Locality 125. USNM 647593.

3. *Macrocallista* (*Paradione*) *maculata* (Linné) (p. 689).
Right valve of internal mold of articulated specimen. Length 47.3 mm. Locality 101h. USNM 647697.

4. *Anomia peruviana gabbi* Pilsbry and Johnson (p. 603).
Left valve. Length 59.5 mm. Locality 83. USNM 647245.

5, 6. *Nodipecten clydonus* Woodring, n. sp. (p. 599).
Type, left valve (fig. 5) and right valve (fig. 6) of articulated specimen. Length 98 mm. Locality 76. USNM 647127.

7. *Pitar* (*Hyphantosoma*) aff. *P.* (*H.*) *centangulatus* Brown and Pilsbry (p. 686).
Left valve. Length (incomplete) 25.3 mm. Locality 116a. USNM 647632.



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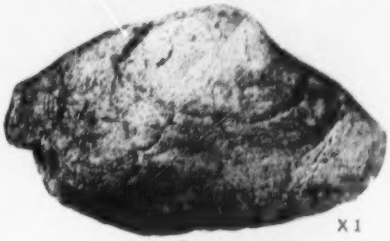

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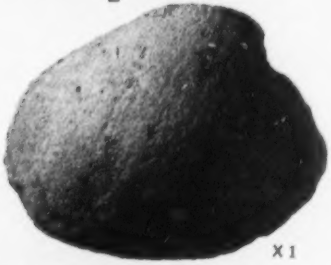

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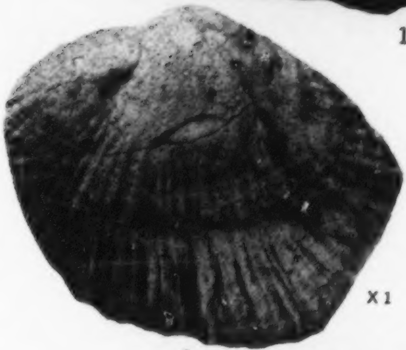

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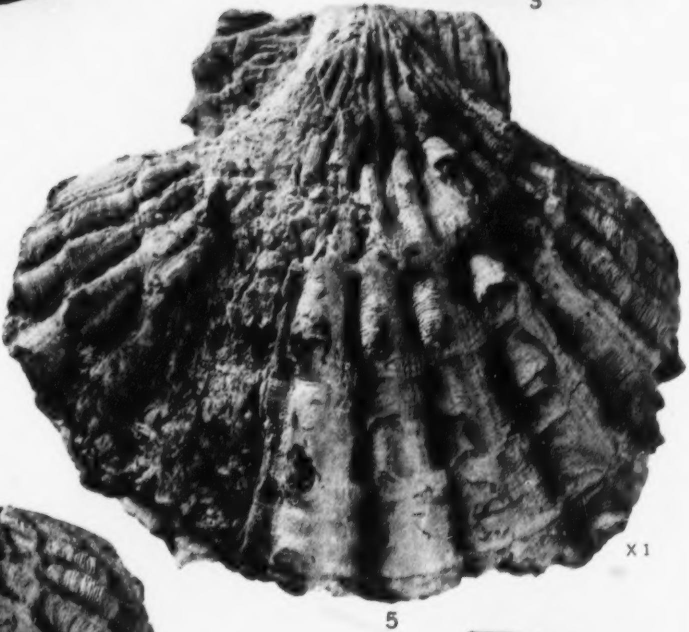

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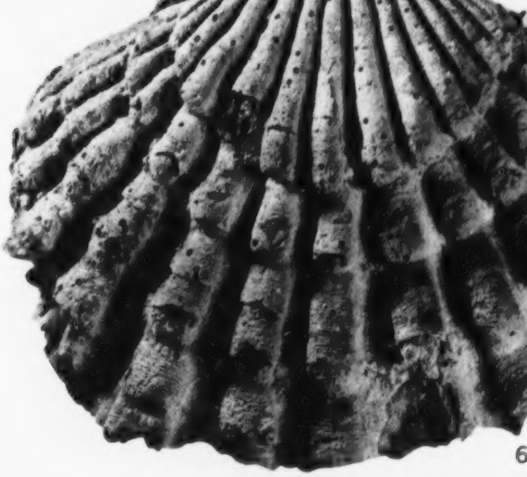

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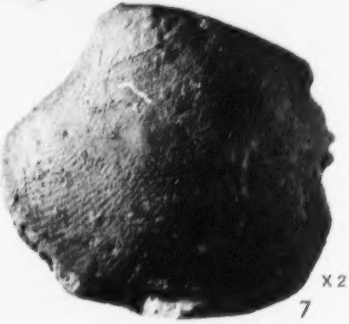

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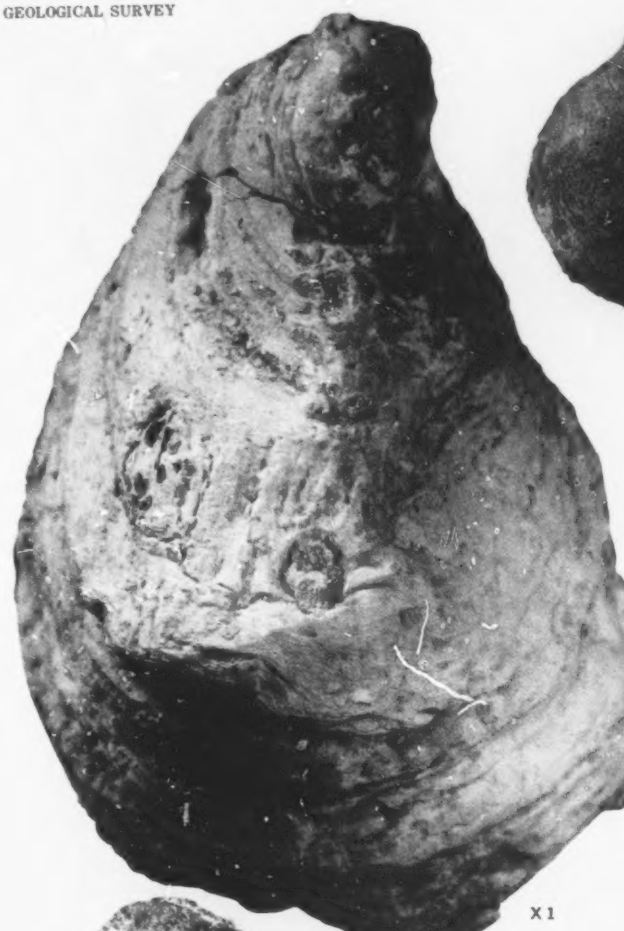
EARLY MIOCENE MOLLUSKS FROM LA BOCA FORMATION (FIGS. 2, 3, 7), AND LOWER MEMBER OF ALHAJUELA FORMATION (FIGS. 1, 4-6)

PLATE 102

FIGURES 1, 5. *Crassostrea cahobasensis* (Pilsbry and Brown) (p. 610).
    1. Left valve. Length 100 mm. Locality 74. USNM 647292.
    5. Right valve of articulated specimen. Length 99 mm. Locality 74. USNM 647293.
2. *Dosinia (Dosinia) delicatissima* Brown and Pilsbry (p. 694).
    Left valve of articulated specimen. Length 44 mm. Locality 101h. USNM 647703.
3, 4. *Semele chipolana* Dall (p. 676).
    3. Left valve of articulated specimen. Length 43.5 mm. Locality 119a. USNM 647612.
    4. Left valve of articulated specimen. Length 50 mm. Locality 89. USNM 647613.
6. *Chione (Chionopsis) eurylopas* Woodring, n. sp. (p. 701).
    Type, left valve. Length 36.6 mm. Locality 99b. USNM 647727.
7. *Florimetis trinitaria* (Dall) (p. 670).
    Right valve of internal mold of articulated specimen. Length 60 mm. Locality 82a. USNM 647595.



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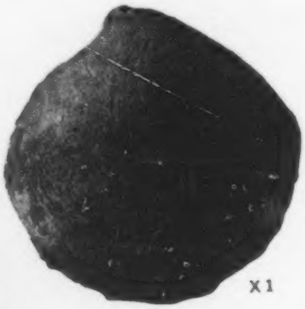

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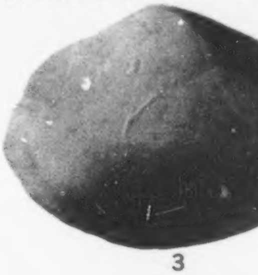

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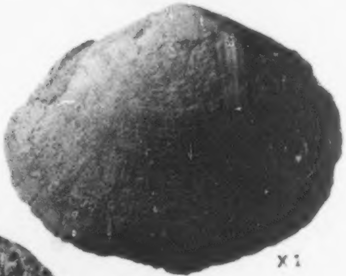

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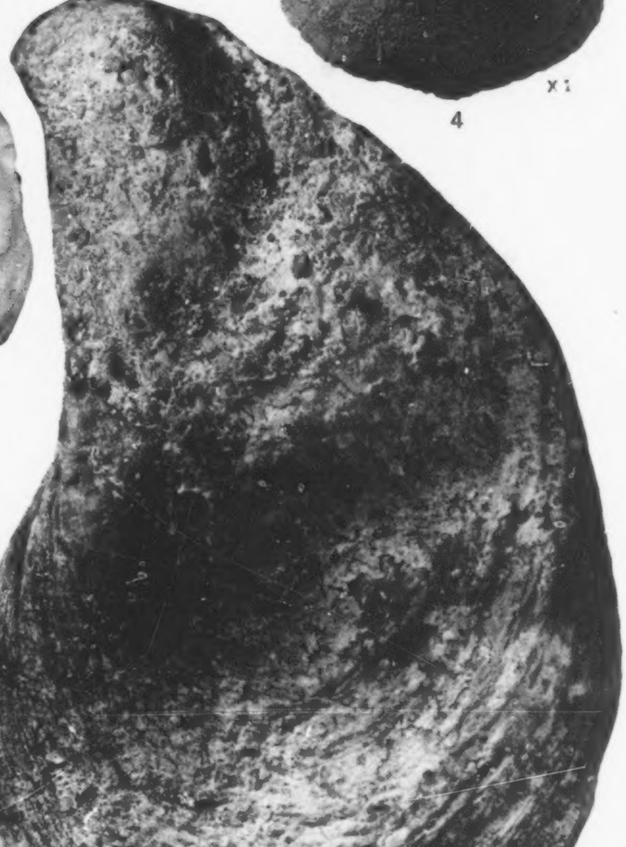

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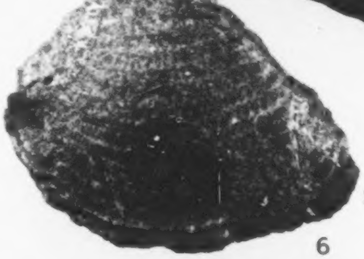

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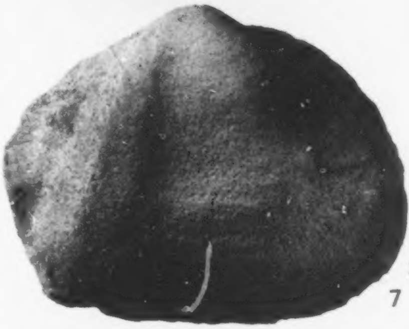

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EARLY MIOCENE MOLLUSKS FROM LA BOCA FORMATION (FIGS. 2, 3, 6), LOWER MEMBER OF ALHAJUELA FORMATION (FIGS. 1, 5, 7), AND UPPER MEMBER OF ALHAJUELA FORMATION (FIG. 4)

PLATE 103

FIGURES 1, 5. *Anomia peruviana gabbi* Pilsbry and Johnson (p. 603).
    1. Left valve. Length 38.7 mm. Locality 83. USNM 647247.
    5. Bizarre left valve. Length 37.9 mm. Locality 83. USNM 647246.

2. *Dosinia* (*Dosinia*) aff. *D. ponderosa titan* Maury (p. 696).
   Right valve of internal mold of articulated specimen that shows some sculpture. Length 85 mm. Locality 89. USNM 647706.

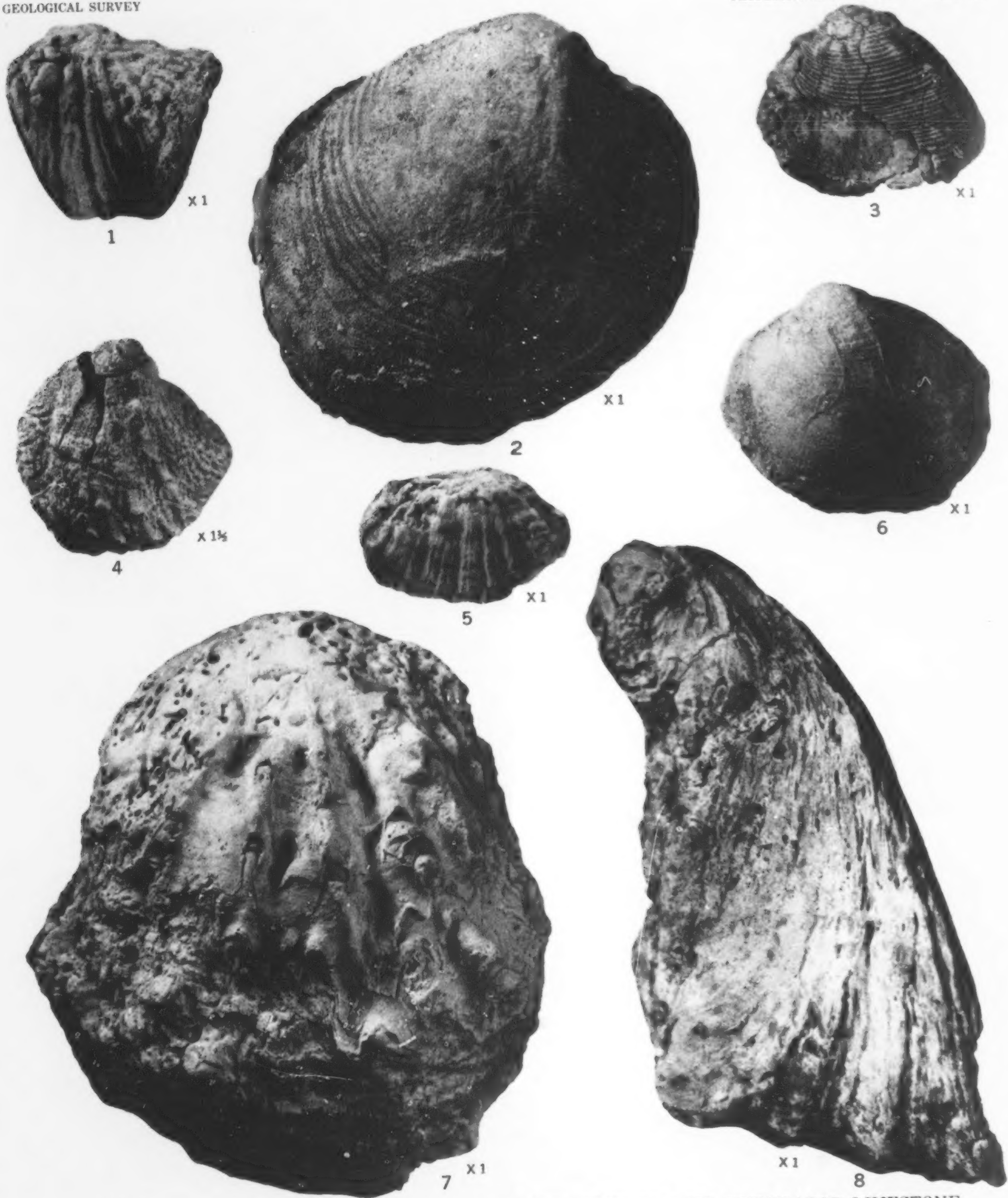
3. *Lamelliconcha* cf. *L. aequicincta* (Spieker) (p. 688).
   Left valve. Length (practically complete) 42.3 mm. Locality 116a. USNM 647691.

4. *Arcinella* sp. (p. 630).
   Right valve. Length 26.2 mm. Locality 116a. USNM 647414.

6. *Periglypta tarquinia* (Dall) (p. 680).
   Left valve of internal mold of articulated specimen that shows some sculpture. Length 48.6 mm. Locality 117b. USNM 647627.

7. *Hyotissa haitensis* (Sowerby) (p. 607).
   Left valve. Length 110 mm. Locality 76. USNM 647281.

8. *Crassostrea cahobasensis* (Pilsbry and Brown) (p. 610).
   Left valve. Length 100 mm. Locality 74. USNM 647292.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EARLY MIOCENE MOLLUSKS FROM LA BOCA FORMATION AND ITS EMPERADOR LIMESTONE MEMBER (FIGS. 3, 4, 6), LOWER MEMBER OF ALHAJUELA FORMATION (FIGS. 1, 5, 7, 8), AND UPPER MEMBER OF ALHAJUELA FORMATION (FIG. 2)

PLATE 104

FIGURES 1, 2, 10. *Flabellipecten gatunensis gatunensis* (Toula) (p. 584).

1, 2. Right (fig. 1) and left (fig. 2) valves of articulated specimen. Length (incomplete) 87.5 mm. Locality 82a. USNM 646981.

10. Right valve. Length 116.5 mm. Locality 91. USNM 646982.

3, 4, 8. *Pecten* (*Euvola*) *bowdenensis* Dall (p. 580).

3. Left valve. Length 27.8 mm. Locality 184. USNM 646986.

4. Right valve. Length (incomplete) 27.5 mm. Locality 182. USNM 646985.

8. Right valve. Length (incomplete) 17 mm. Locality 182a. USNM 646984.

5. *Anomia simplex* d'Orbigny (p. 604).

Left valve. Length (practically complete) 38.2 mm. Locality 169. USNM 647248.

6. *Limatula asymbleta* Woodring, n. sp. (p. 605).

Type, right valve. Length 4 mm. Locality 138. USNM 647249.

7, 11. *Argopecten levicostatus* (Toula) (p. 596).

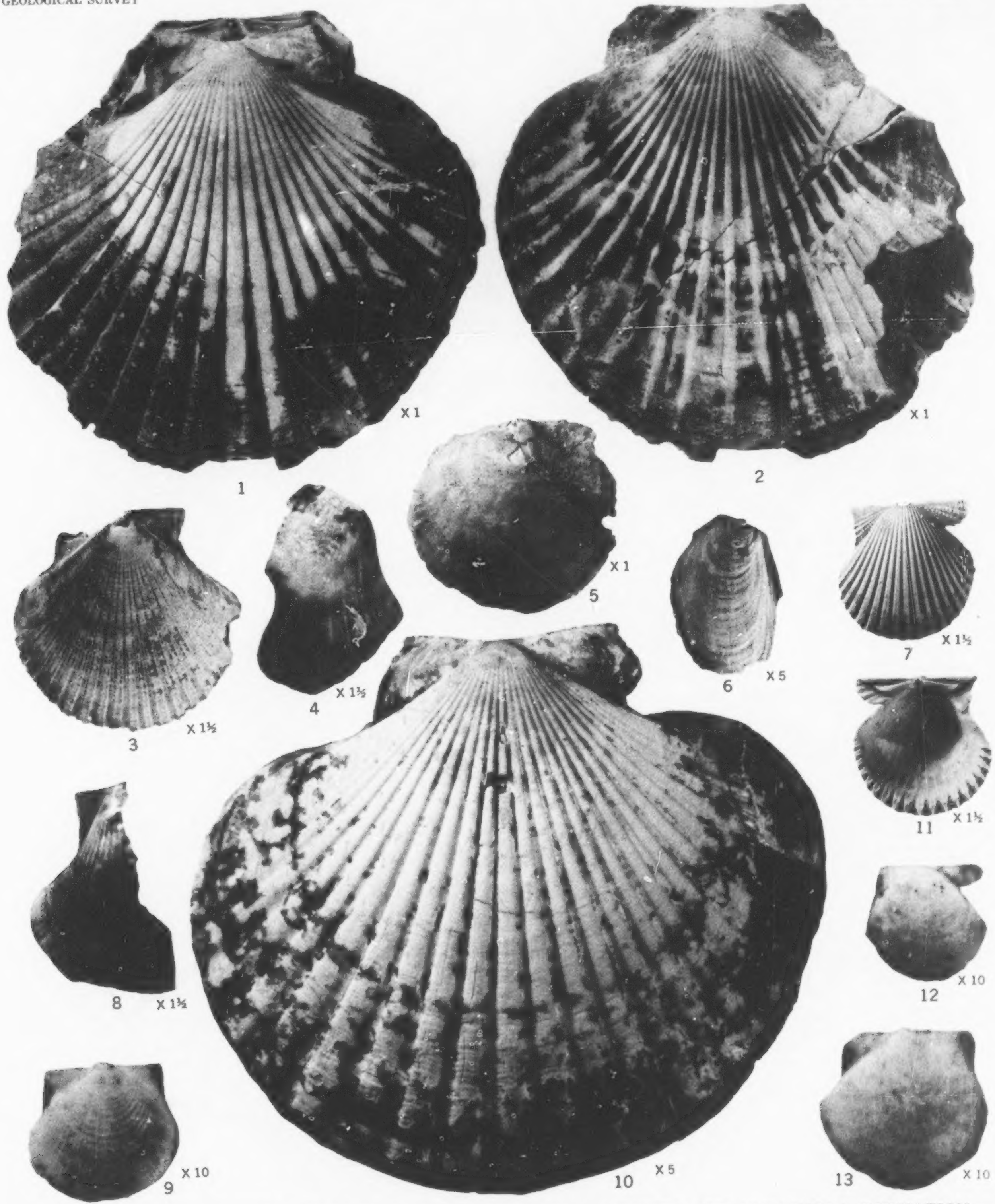
Exterior (fig. 7) and interior (fig. 11) of immature right valve. Length 17 mm. Locality 161c. USNM 647230.

9, 12, 13. *Cyclopecten oligolepis* (Brown and Pilsbry) (p. 576).

9. Left valve. Length 2.8 mm. Locality 147b. USNM 647221.

12. Right valve. Length 2.2 mm. Locality 147b. USNM 647220.

13. Left valve. Length 3.1 mm. Locality 155c. USNM 647222.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EARLY MIOCENE MOLLUSKS FROM LOWER AND UPPER MEMBERS OF ALHAJUELA FORMATION (FIGS. 1, 2, 10) AND MIDDLE MIOCENE MOLLUSKS FROM GATUN FORMATION

PLATE 105

FIGURES 1–3, 7. *Argopecten venezuelanus* (F. and H. Hodson) (p. 596).

1. Right valve. Length 42.3 mm. Locality 85a. USNM 647219.

2, 3, 7. Right (fig. 2) and left (fig. 3) valves, and umbonal view of articulated specimen. Length 37.7 mm. Locality 90. USNM 647218.

4–6, 8, 9. *Leptopecten ecnomius* Woodring, n. sp. (p. 595).

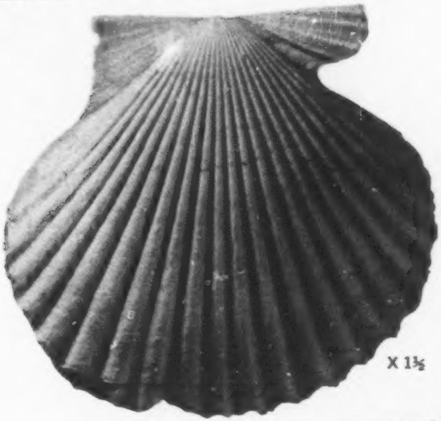
4. Right valve showing strong concentric sculpture. Length 21 mm. Locality 138d. USNM 647129.

5, 6. Right (fig. 5) and left (fig. 6) valves of articulated specimen, auricles intact. Locality 138c. USNM 647130.

8, 9. Right (fig. 8) and left (fig. 9) valves of articulated type. Length 22.7 mm. Locality 136a. USNM 647128.

10, 11. *Hyotissa haitensis* (Sowerby) (p. 607).

Right valve. Length 87 mm. Locality 76. USNM 647282.



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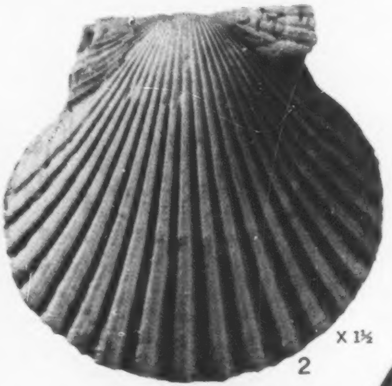

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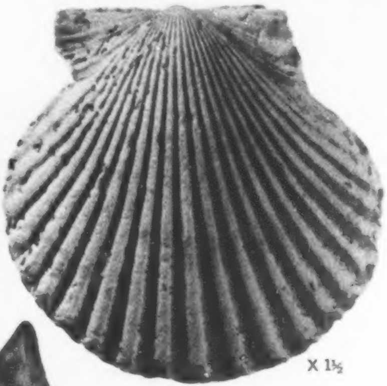

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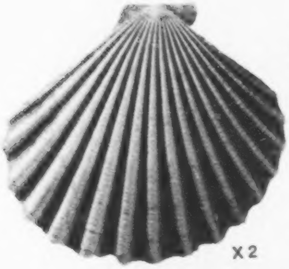

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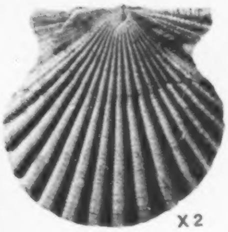

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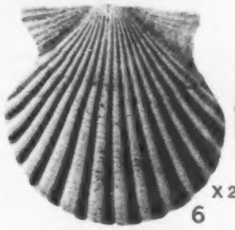

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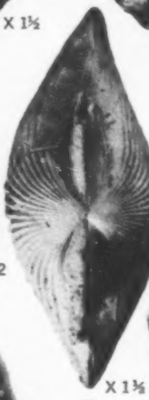

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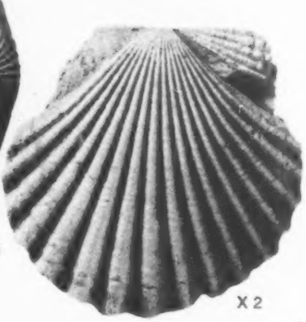

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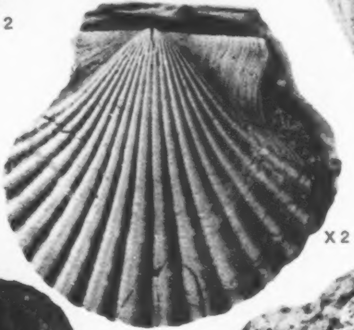

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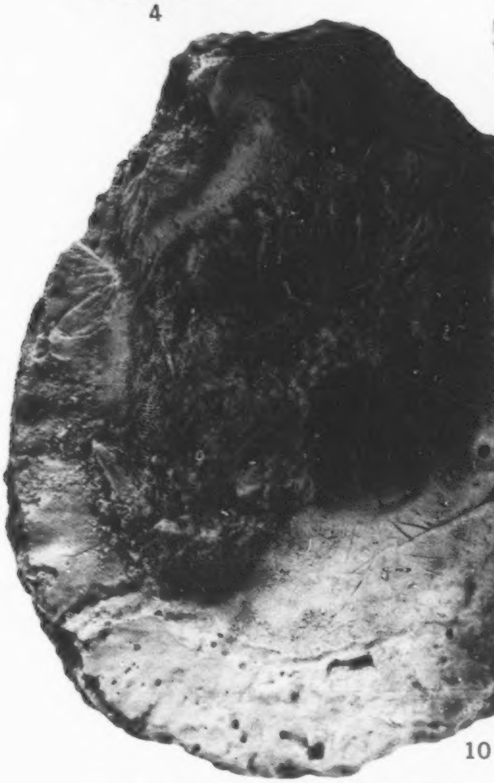

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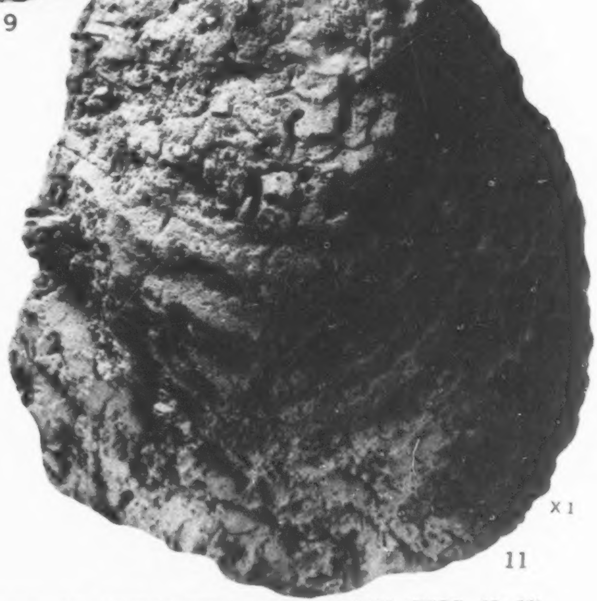


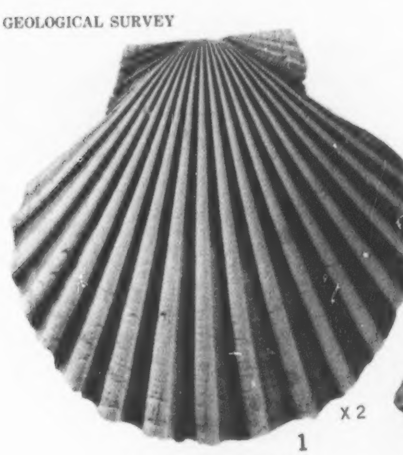
11

EARLY MIOCENE MOLLUSKS FROM LOWER MEMBER OF ALHAJUELA FORMATION (FIGS. 10, 11), UPPER MEMBER OF ALHAJUELA FORMATION (FIGS. 1, 2, 3, 7), AND MIDDLE MIOCENE MOLLUSKS FROM GATUN FORMATION

PLATE 106

FIGURES 1, 3–5. *Lepidopecten scissuratus* (Dall) (p. 593).
- 1. Right valve. Length 30 mm. Locality 155b. USNM 647227.
- 3. Type, left valve. Length 30.7 mm. Locality Mount Hope. USNM 113670.
- 4. Right valve. Length 28.3 mm. Locality 147h. USNM 647226.
- 5. Left valve. Length 22.8 mm. Locality 155. USNM 647225.

2, 6, 7. *Crassostrea cahobasensis* (Pilsbry and Brown) (p. 619).
- 2, 7. Left valve. Length 82 mm. Locality 167. USNM 647294.
- 6. Right valve. Length 83 mm. Locality 167. USNM 647295.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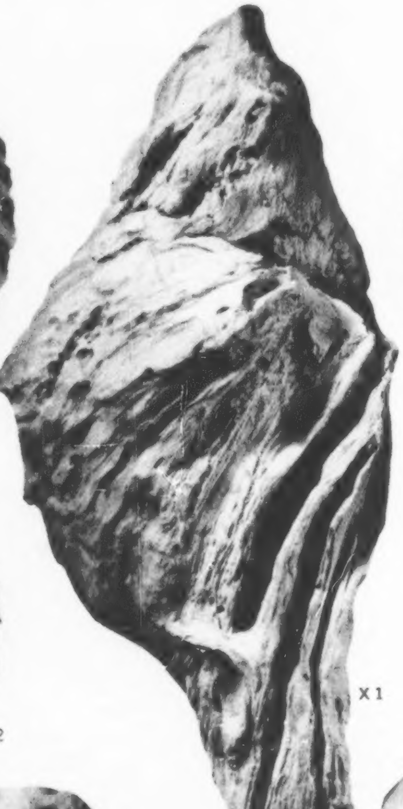
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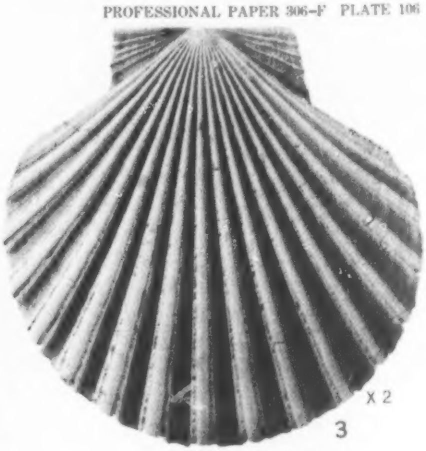
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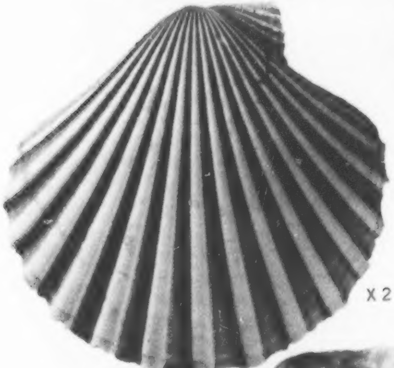
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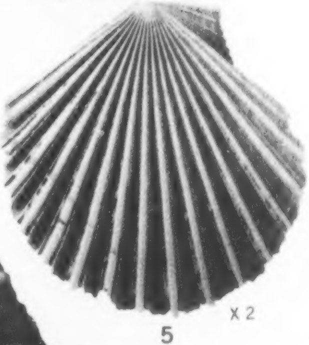
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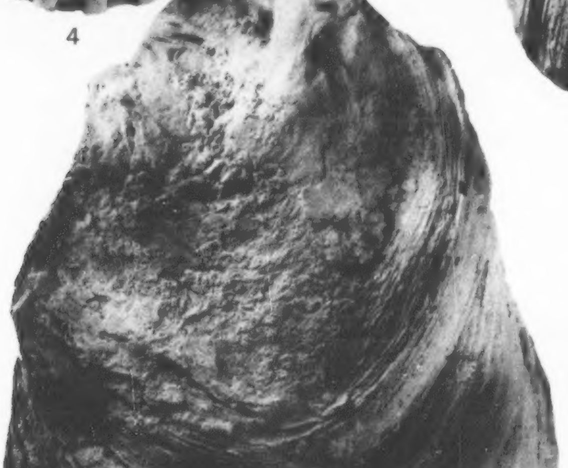
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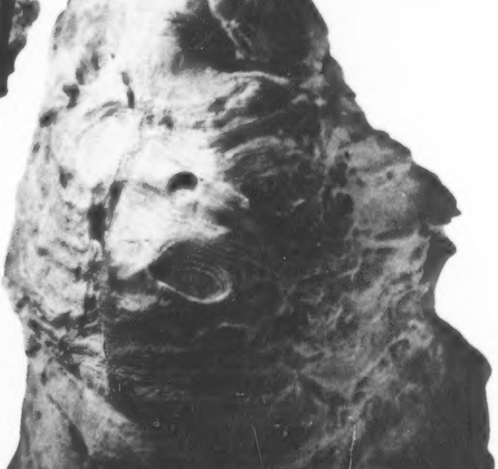
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7

MIDDLE MIOCENE MOLLUSKS FROM GATUN FORMATION

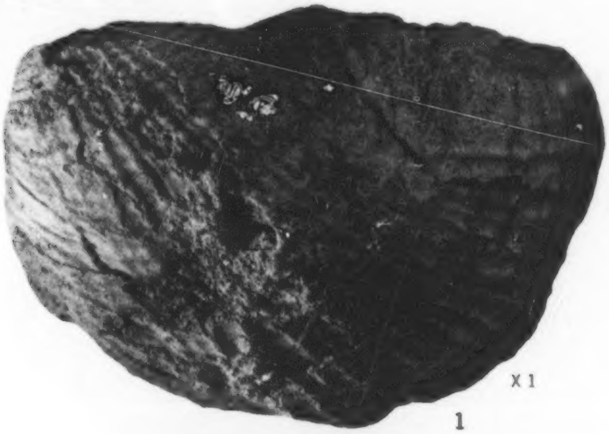
PLATE 107

FIGURE 1. *Pholadomya falconensis* F. and H. Hodson (p. 720).
    Left valve of internal mold of articulated specimen. Length 88.5 mm. Locality 90a. USNM 647798.

2, 4. *Dinocardium robustum* [Lightfoot], small form (p. 646).
    2. Left valve internal mold. Length 70 mm. Locality 88. USNM 647509.
    4. Right valve of internal mold of articulated specimen. Length 75.5 mm. Locality 89. USNM 647508.

3, 6. *Flabellipecten gatunensis gatunensis* (Toula) (p. 584).
    Exterior (fig. 3) and interior (fig. 6) of right valve. Length 92.5 mm. Locality 138c. USNM 646987.

5. *Aequipecten plurinominis* (Pilsbry and Johnson) (p. 592).
    Right valve. Length 44.8 mm. Locality 144. USNM 647224.



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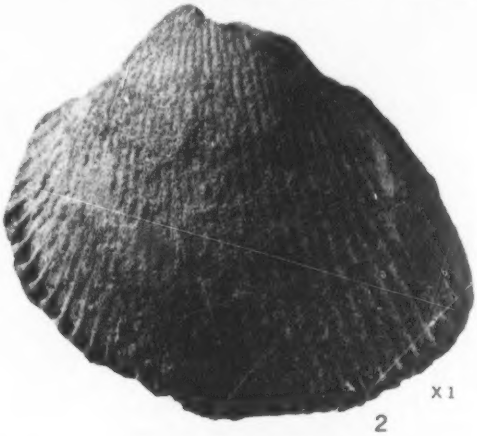

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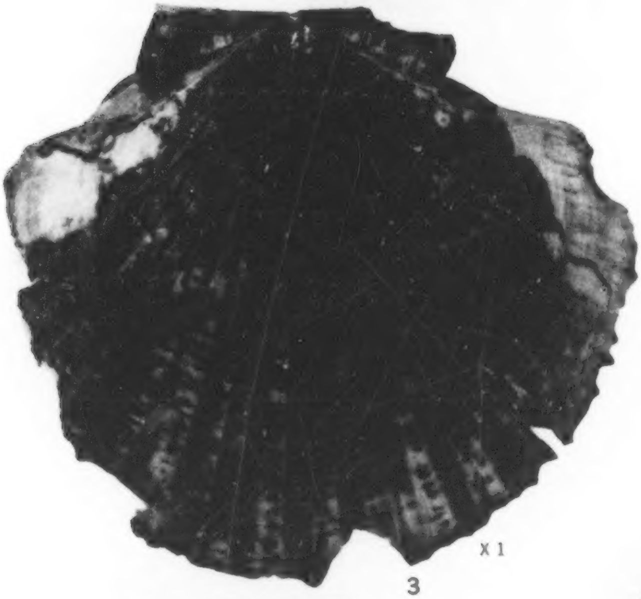

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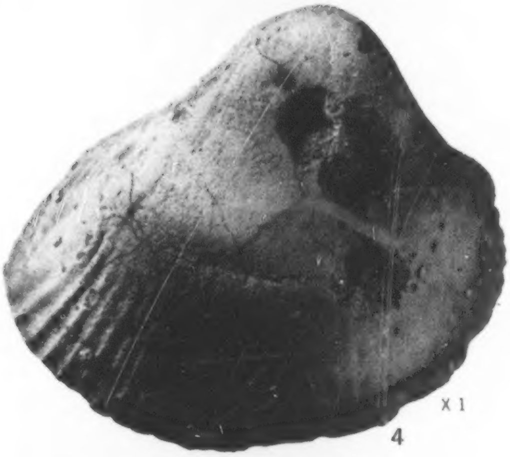

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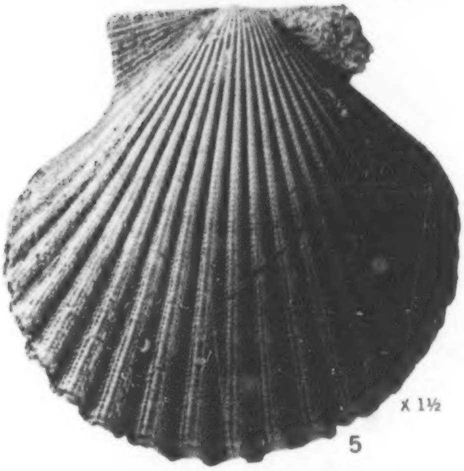

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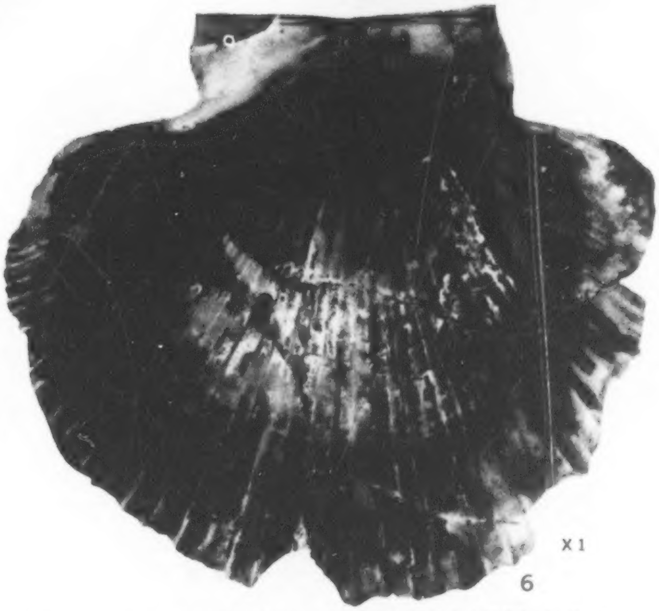

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6

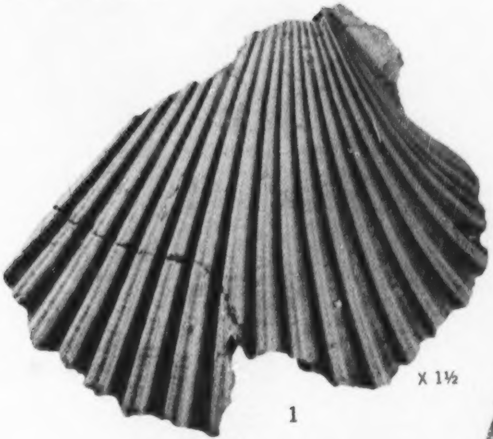
EARLY MIOCENE MOLLUSKS FROM UPPER MEMBER OF ALHAJUELA FORMATION (FIGS. 1, 2, 4) AND MIDDLE MIOCENE MOLLUSKS FROM GATUN FORMATION (FIGS. 3, 5, 6)

PLATE 108

FIGURES 1–3. *Pecten (Oppenheimopecten) reliquus* Brown and Pilsbry (p. 579).
- 1. Right valve. Length (incomplete) 47.7 mm. Locality 147a. USNM 646983.
- 2, 3. Left valve (fig. 2, incomplete length 34.7 mm) and right valve (fig. 3, incomplete length 34.9 mm) syntypes. Gatun Dam spillway excavation. Acad. Nat. Sci. Philadelphia 3882.

4–6. *Aequipecten plurinominis* (Pilsbry and Johnson) (p. 592).
- 4, 5. Right valve (fig. 4) and umbonal view (fig. 5) of articulated specimen. Length 43.2 mm. Locality 143. USNM 647223.
- 6. Right valve. Length 44.8 mm. Locality 144. USNM 647224.

7, 8. *Amusium toulae* (Brown and Pilsbry) (p. 588).
- 7. Left valve of articulated specimen. Length 82 mm. Locality 154. USNM 647197.
- 8. Interior of right valve. Length 80.7 mm. Locality 154. USNM 647196.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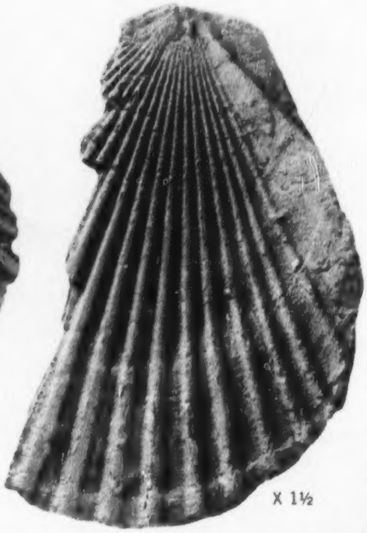
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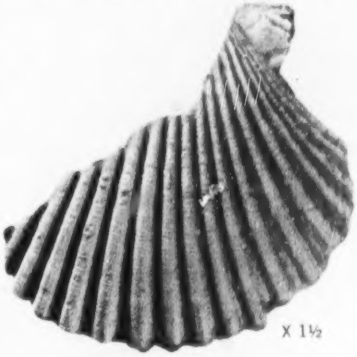
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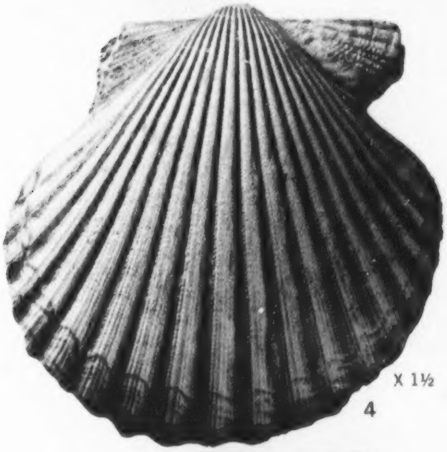
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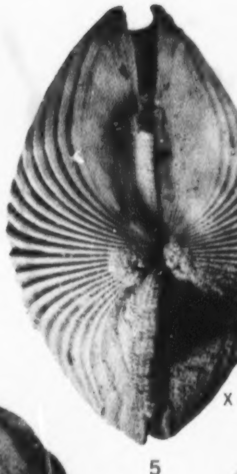
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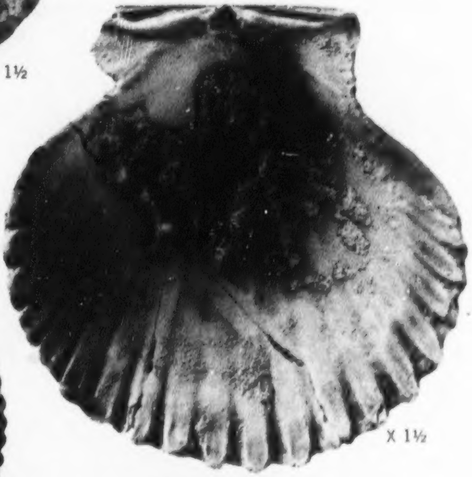
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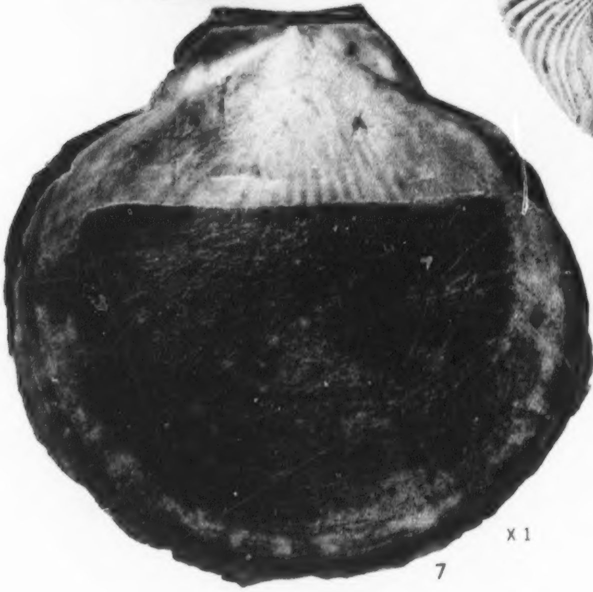
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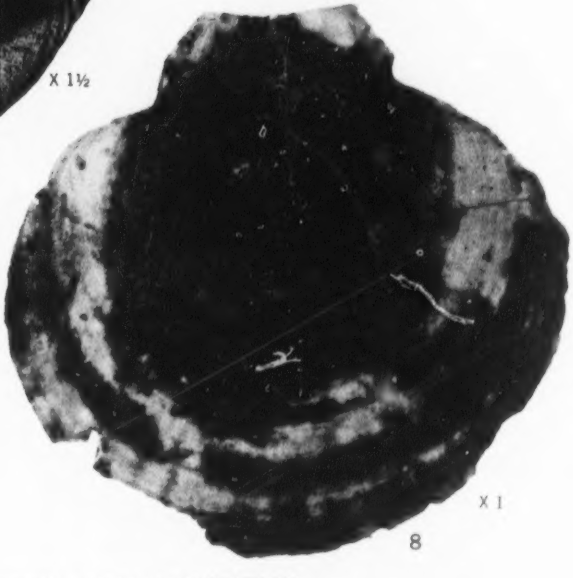
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8

MIDDLE MIOCENE MOLLUSKS FROM GATUN FORMATION

PLATE 109

FIGURES 1, 2, 7, 8. *Dimya phaidra* Woodring, n. sp. (p. 602).

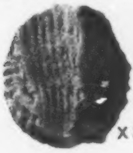
- 1, 2. Paratype, right valve. Attachment area forming vertical trough (fig. 1). Length 6.4 mm. Locality 185. USNM 647206.
- 7, 8. Type, left valve. Length 9.9 mm. Locality 185. USNM 647205.

3–5. *Lopha frons* (Linné) (p. 613).

- 3, 5. Right valve. Length 20.5 mm. Locality 160a. USNM 647304.
- 4. Right valve. Length 13.9 mm. Locality 138c. USNM 647303.

6, 9–12. *Hyotissa haitensis* (Sowerby) (p. 607).

- 6, 10. Right valve. Length 50.3 mm. Locality 138c. USNM 647283.
- 9, 11. Paired left (fig. 9) and right (fig. 11) valves. Length 90 mm. Locality 175. USNM 647285.
- 12. Left valve. Length 93.5 mm. Locality 159b. USNM 647284.



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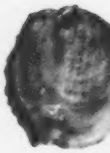

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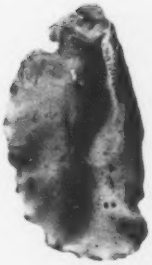

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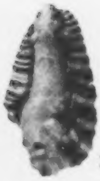

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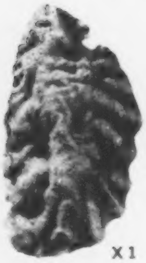

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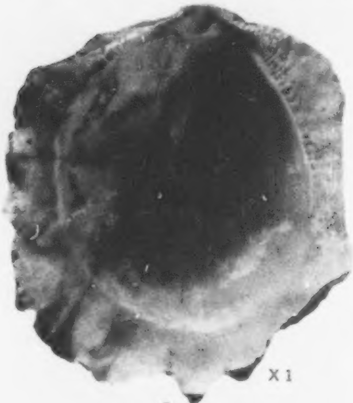

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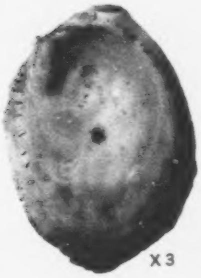

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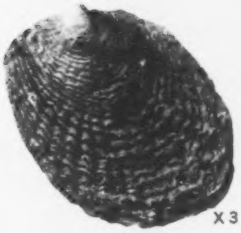

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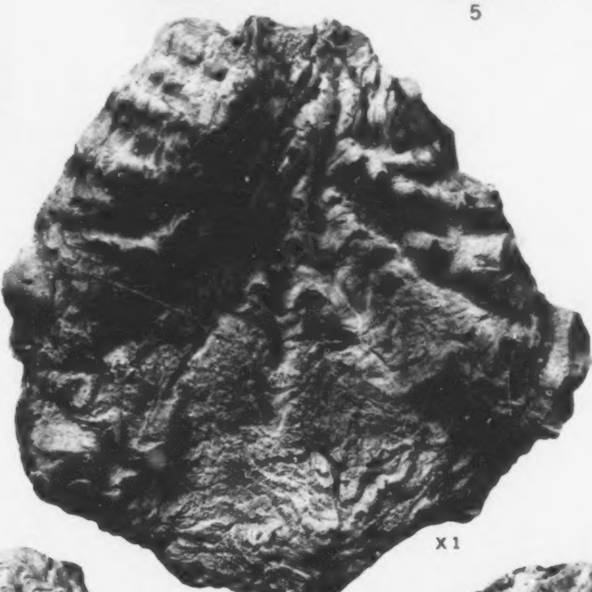

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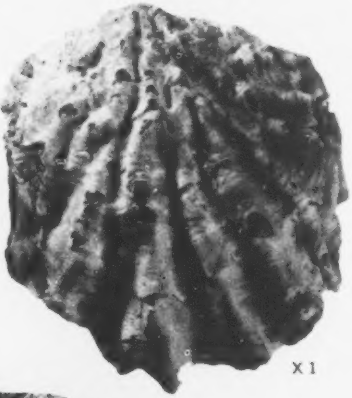

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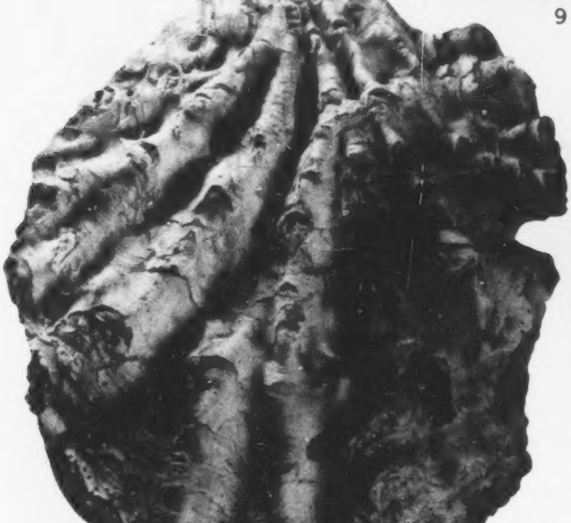

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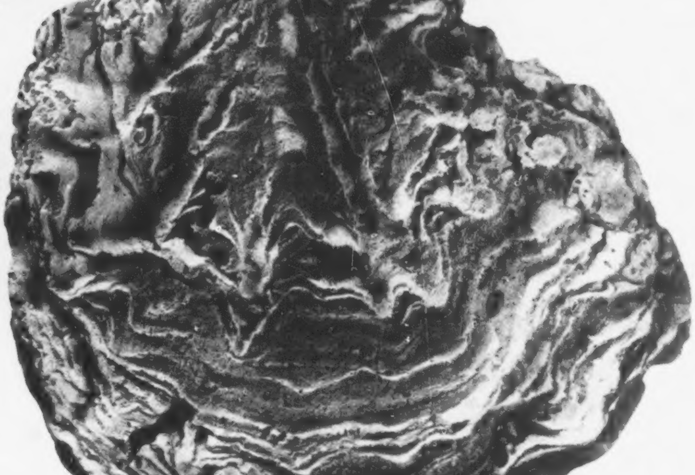


12

MIDDLE MIOCENE MOLLUSKS FROM GATUN FORMATION

PLATE 110

FIGURES 1, 2, 10. *Argopecten levicostatus* Toula (p. 596).
- 1, 2. Right valve. Length 36.6 mm. Locality 154. USNM 647228.
- 10. Left valve. Length 33.6 mm. Locality 154. USNM 647229.

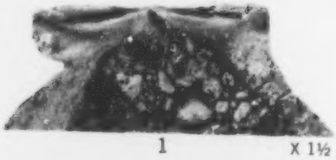
3. *Aequipecten plurinominis* (Pilsbry and Johnson) (p. 592).
Left valve of articulated specimen. Length 43.2 mm. Locality 143. USNM 647223.

4–9. *Ostrea equestris heothina* Woodring, n. subsp. (p. 612).
- 4, 5. Type, left valve. Length 25 mm. Locality 144a. USNM 647298.
- 6, 7. Paratype, right valve. Length 19.6 mm. Locality 144a. USNM 647299.
- 8, 9. Arcuate left valve. Length 28.5 mm. Locality 144a. USNM 647300.

11. *Periglypta* cf. *P. caribbeana* (Anderson) (p. 680).
Right valve. Length (incomplete) 72 mm. Locality 89. USNM 647628.

12, 14. *Pecten* (*Oppenheimopecten*) *colpotus* Woodring, n. sp. (p. 579).
- 12. Paratype, right valve. Length 32.5 mm. Locality 83. USNM 646979.
- 14. Type, right valve. Length (almost complete) 48.5 mm. Locality 82. USNM 646978.

13. *Flabellipecten gatunensis gatunensis* (Toula) (p. 584).
Right valve. Length (incomplete) 64.5 mm. Locality 76. USNM 646980.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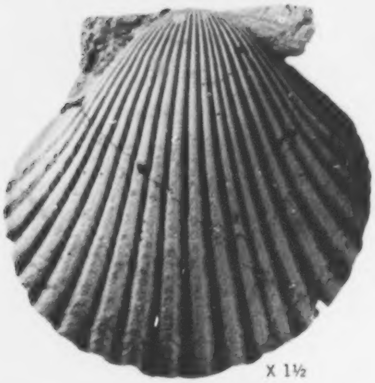
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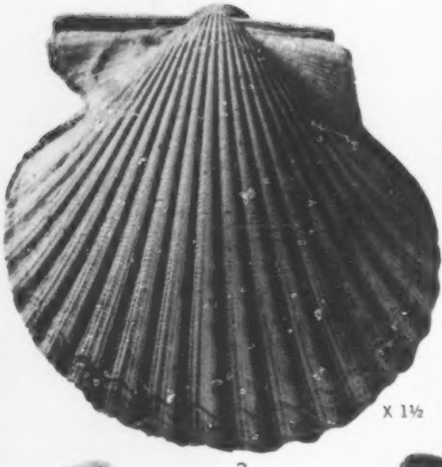
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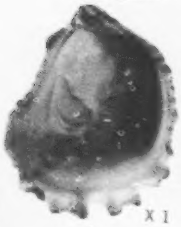
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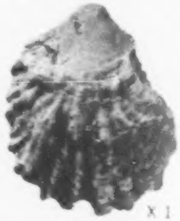
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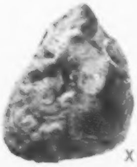
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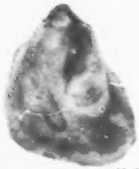
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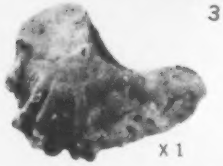
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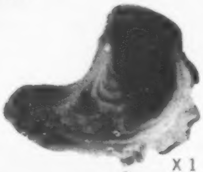
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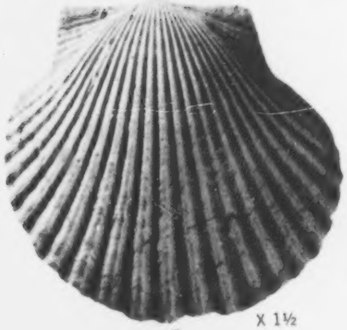
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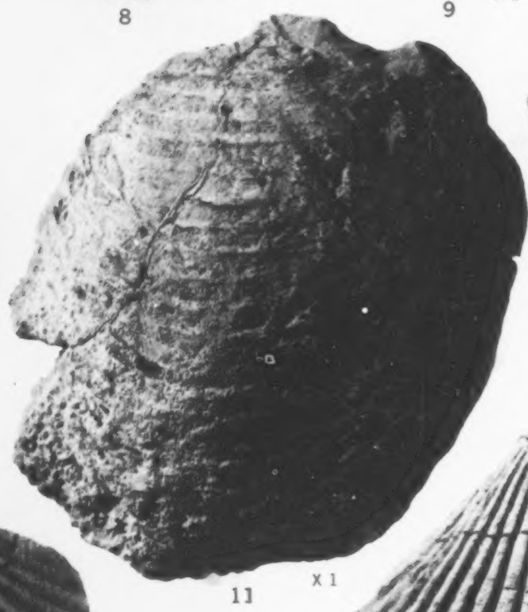
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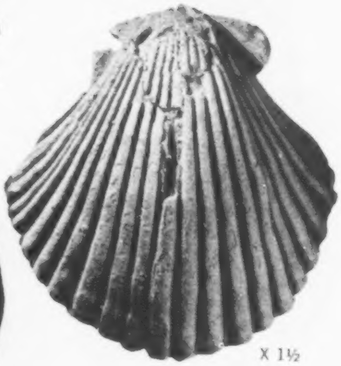
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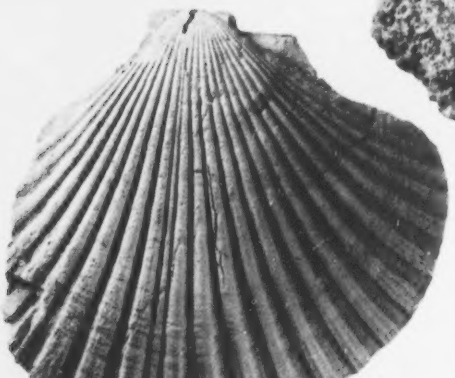
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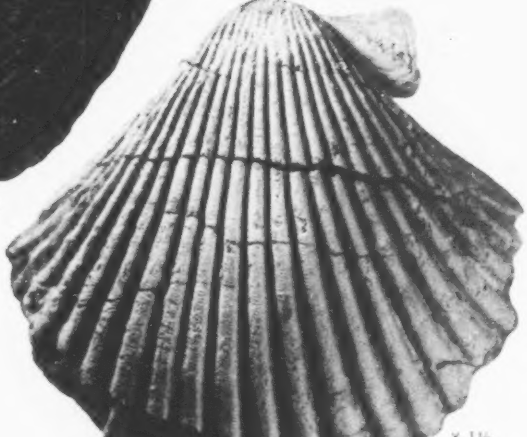
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EARLY MIOCENE MOLLUSKS FROM LOWER (FIGS. 12–14) AND UPPER (FIG. 11) MEMBERS OF ALHAJUELA FORMATION AND MIDDLE MIOCENE MOLLUSKS FROM GATUN FORMATION

PLATE 111

FIGURES 1, 2, 14. *Miltha chipolana* (Dall)? (p. 619).

1, 2. Exterior (fig. 1) and interior (fig. 2) of left valve. Length 22.9 mm. Locality 155. USNM 647313.

14. Anastomosing radial sculpture on worn central part of same valve.

3, 4, 7, 9, 11. *Lucina (Lepilucina) gratis* Olsson (p. 615).

3, 4. Right (fig. 3) and left (fig. 4) valves of articulated specimen. Length 25.2 mm. Locality 139g. USNM 647315.

7, 11. Left valve. Length 26.6 mm. Locality 139g. USNM 647358.

9. Umbonal view of articulated specimen shown in figs. 3, 4.

5, 6. "*Lucinoma*" sp. (p. 621).

Dorsal part of left valve. Length (incomplete) 8.8 mm. Locality 138d. USNM 647334.

8, 12. *Luciniscа bocasensis* (Olsson) (p. 617).

Left valve. Length 21.4 mm. Locality 155. USNM 647311.

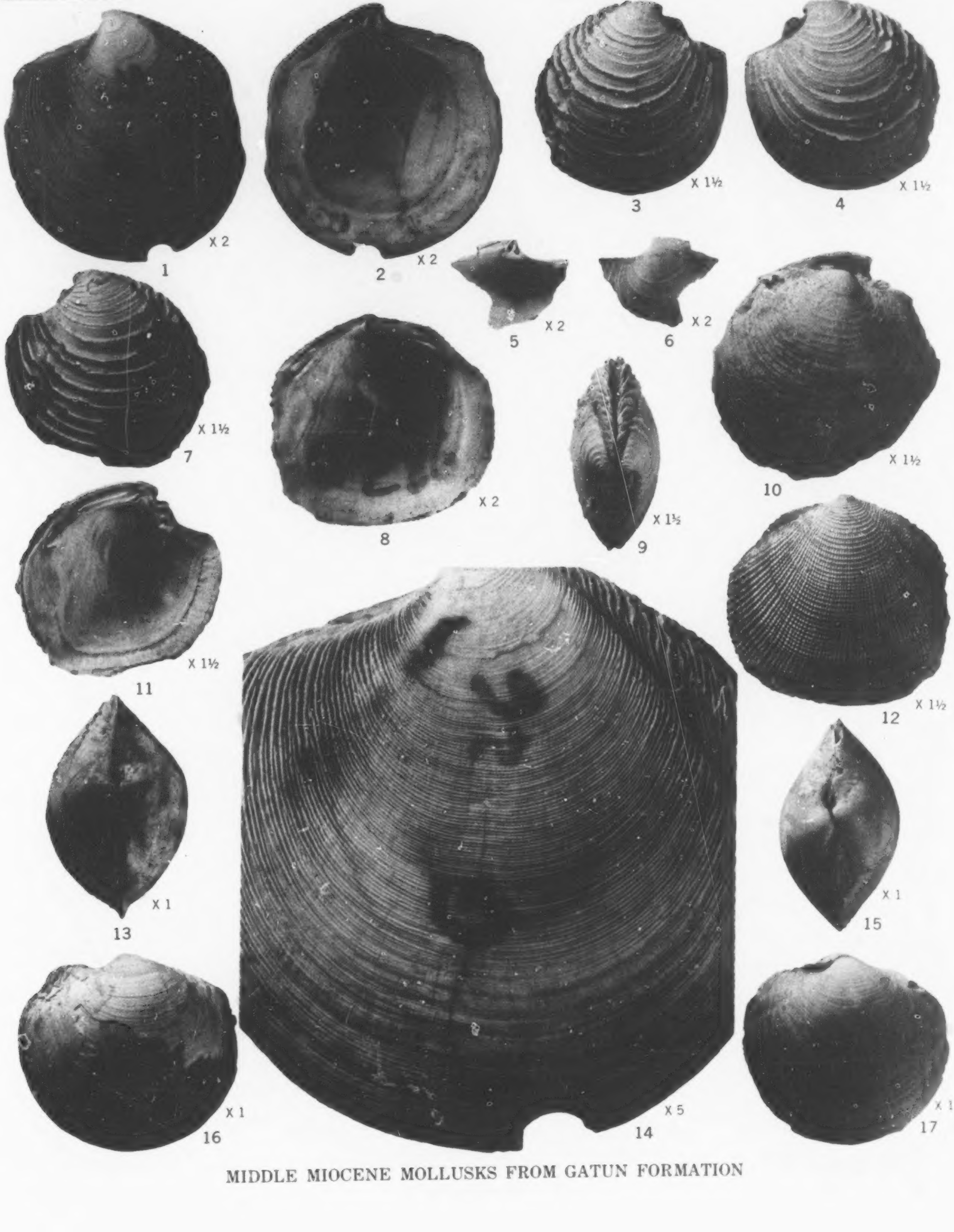
10. *Lucinoma* sp. b. (p. 620).

Right valve of articulated specimen. Length (almost complete) 30 mm. Locality 147j. USNM 647333.

13, 15–17. *Pegophysema janus* (Dall) (p. 622).

13, 16. Left valve of articulated specimen. Length 41.4 mm. Locality 156. USNM 647357.

15, 17. Left valve of articulated specimen. Length 39.8 mm. Locality 155. USNM 647356.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MIDDLE MIOCENE MOLLUSKS FROM GATUN FORMATION

PLATE 112

FIGURES 1, 6, 10, 11. *Chama berjadinensis* F. Hodson (p. 630).

1.6. Left (fig. 1) and right (fig. 6) valves of articulated specimen. Length 35.7 mm. Locality 138c. USNM 647412.

10, 11. Exterior (fig. 10) and interior (fig. 11) of left valve. Length 32 mm. Locality 139c. USNM 647413.

2–4. *Bellucina actinus* (Dall) (p. 616).

2. Left valve. Length 3.9 mm. Locality 147b. USNM 647310.

3, 4. Right valve. Length 4.35 mm. Locality 147b. USNM 647309.

5, 8, 9, 12. *Arcinella arcinella* (Linné), small form (p. 631).

5, 9. Right valve. Length 31 mm. Locality 138c. USNM 647415.

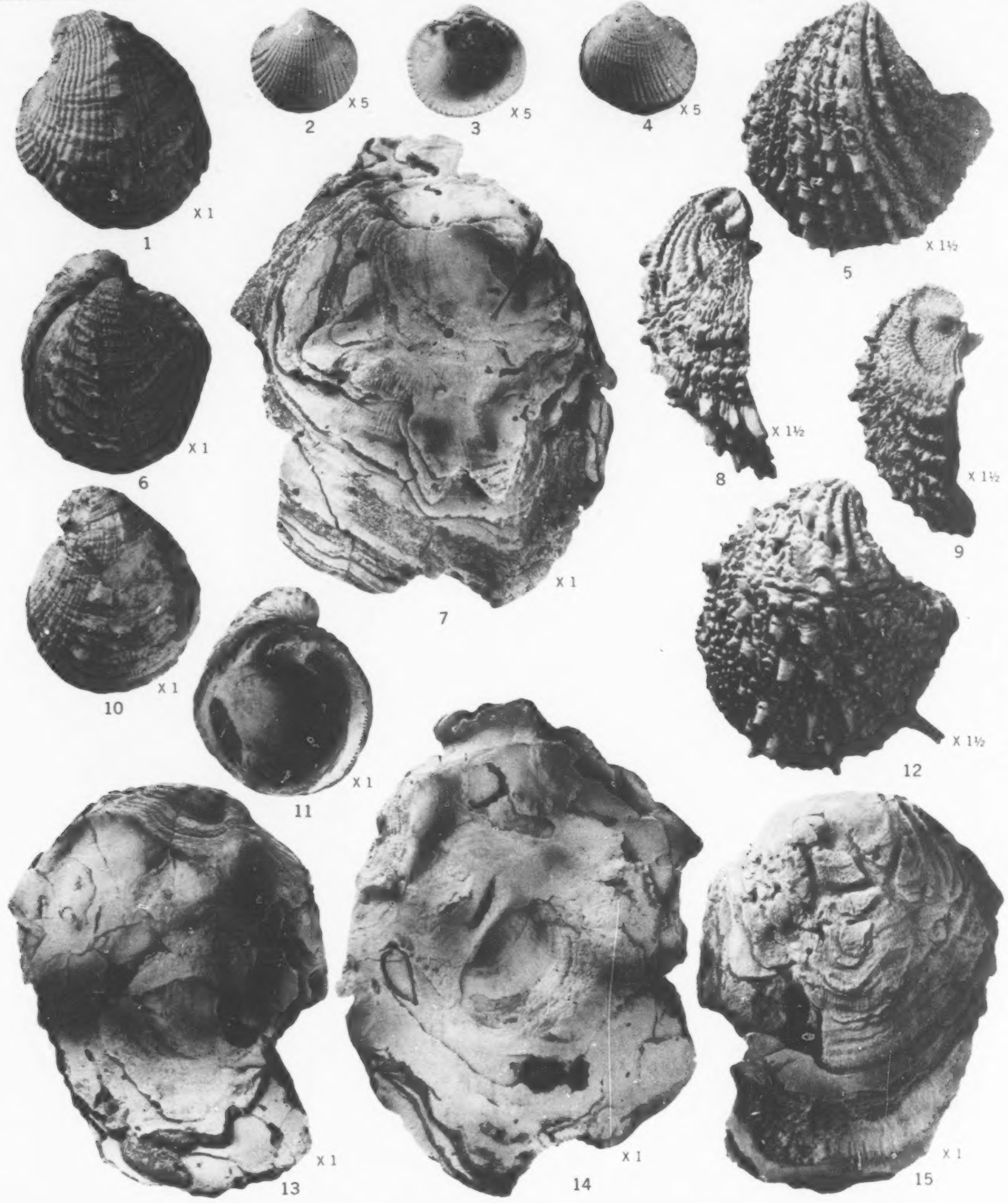
8, 12. Right valve. Length 32.7 mm. Locality 155b. USNM 641416.

7, 13–15. *Pycnodonte* (*Pycnodonte*?) sp. (p. 606).

Matching? right and left valves. Length 82.8 mm. Locality 183. USNM 647279.

7, 14. Exterior (fig. 7) and interior (fig. 14) of right valve.

13, 15. Exterior (fig. 15) and interior (fig. 13) of left valve.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MIDDLE MIOCENE MOLLUSKS FROM GATUN FORMATION

PLATE 113

FIGURES 1–3, 6. *Ervilia valhosierr* Gardner (p. 655).

1. Triangular-ovate left valve. Length 5 mm. Locality 138c. USNM 647527.
2. Elongate left valve. Length 5.8 mm. Locality 169. USNM 647529.
3. Somewhat elongate right valve. Length 5.1 mm. Locality 138. USNM 647528.
6. Immature, elongate, sculptured right valve. Length 3.3 mm. Locality 161c. USNM 647530.

4, 5, 8, 10. *Venericardia* (*Glyptoactis*) *aversa* Pilsbry and Johnson (p. 629).

Left (figs. 4 and 8) and right (figs. 5 and 10) valves of articulated specimen. Length 18.3 mm. Locality 150. USNM 647381.

7, 11, 12. *Chama berjadinensis* F. Hodson (p. 630).

Left (fig. 7) and right (fig. 11) valves, and side view of articulated specimen. Length 36 mm. Locality 139e. USNM 647411.

9, 13. *Arcinella arcinella* (Linné)? (p. 632).

9. Left valve. Length 38.7 mm. Locality 182a. USNM 647418.
13. Left valve. Length 46.2 mm. Locality 182. USNM 647417.

14–16. *Diplodonta* (*Diplodonta*) *homalostriata* Woodring (p. 625).

14, 15. Interior (fig. 14) and exterior (fig. 15) of left valve. Length 6.5 mm. Locality 159d. USGS 647367.

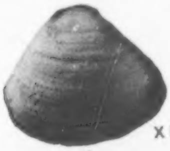
16. Right valve. Length (practically complete) 15 mm. Locality 143. USNM 647366.

17. *Flabellipecten gatunensis tapeinus* Woodring, n. subsp. (p. 585).

Right valve. Length 82.7 mm. Locality 139g. USNM 646989.

18. *Flabellipecten gatunensis gatunensis* (Toula) (p. 584).

Right valve. Length (incomplete) 73 mm. Locality 143. USNM 646988.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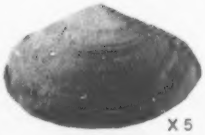
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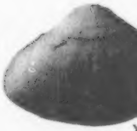
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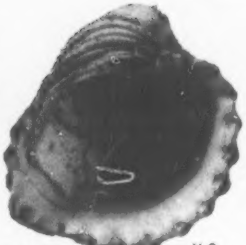
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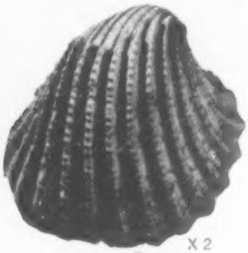
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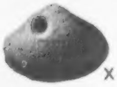
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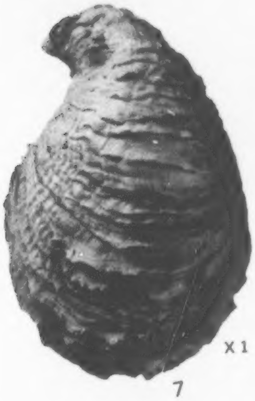
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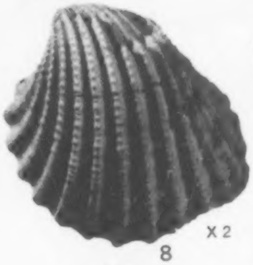
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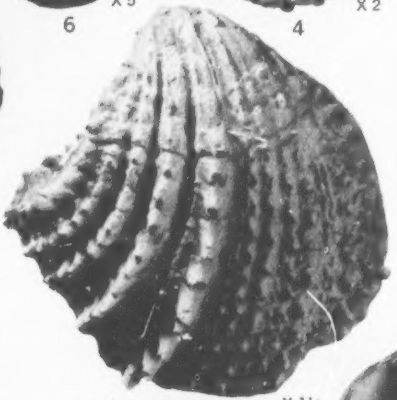
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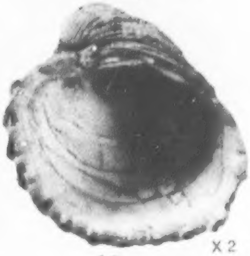
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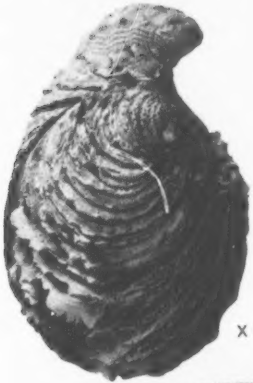
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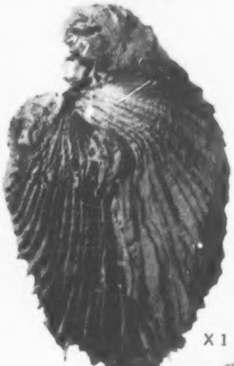
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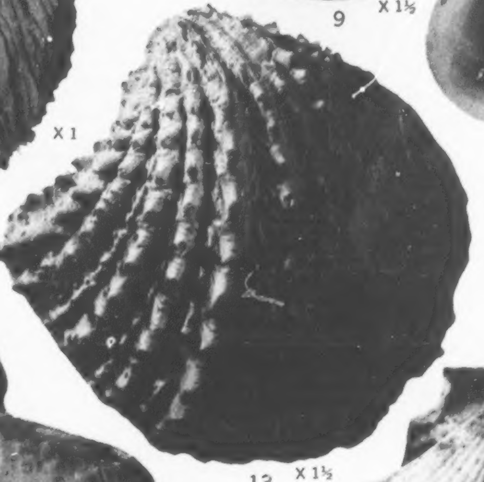
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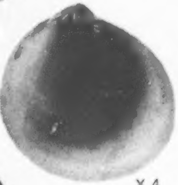
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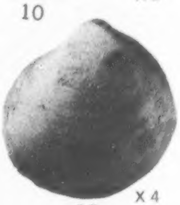
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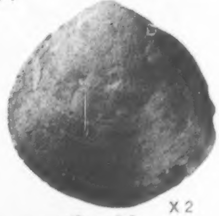
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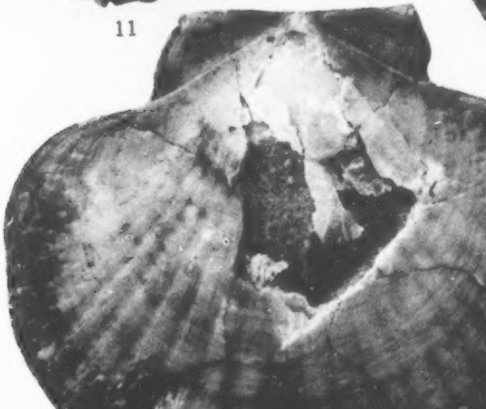
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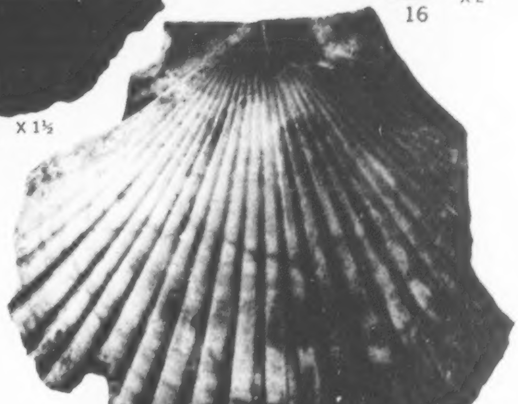
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MIDDLE MIOCENE MOLLUSKS FROM GATUN FORMATION

PLATE 114

FIGURES 1, 2, 6. *Lophocardium gurabicum* (Maury) (p. 645).

- 1. Right valve of internal mold of articulated specimen. Length (almost complete) 39.7 mm. Locality 160. USNM 647507.
- 2, 6. Immature left valve. Length (almost complete) 15.9 mm. Locality 155. USNM 647506.

3-5, 8, 9. *Trigoniocardia* (*Apiocardia*) *aminensis* (Dall) (p. 643).

- 3. Relatively wide form. Right valve. Length 12.8 mm. Locality 138c. USNM 647482.
- 4, 5. Narrow form. Right valve. Length 10.5 mm. Locality 138c. USNM 647481.
- 8. Type. Left valve. Length 10.7 mm. Potrero, Río Amina, Dominican Republic. USNM 113800.
- 9. Narrow form. Right valve. Length 13.5 mm. Locality 139c. USNM 647483.

7. *Mulinia* aff. *M. lateralis* (Say) (p. 650).

Right valve. Length (almost complete) 11.4 mm. Locality 138c. USNM 647515.

10, 11, 14. *Trachycardium* (*Dallocardia*) *dominicense dominicense* (Gabb) (p. 638).

- 10. Left valve of internal mold of articulated specimen. Length 51.5 mm. Locality 139g. USNM 647467.
- 11, 14. Left valve. Length 36.5 mm. Locality 155. USNM 647468.

12, 13. *Raeta hasletti* (Anderson) (p. 653).

Articulated specimen. Length 51.5 mm. Locality 155. USNM 647521.

- 12. Umbonal view.
- 13. Left valve.

15, 16. *Psammotreta hadra* Woodring, n. sp. (p. 669).

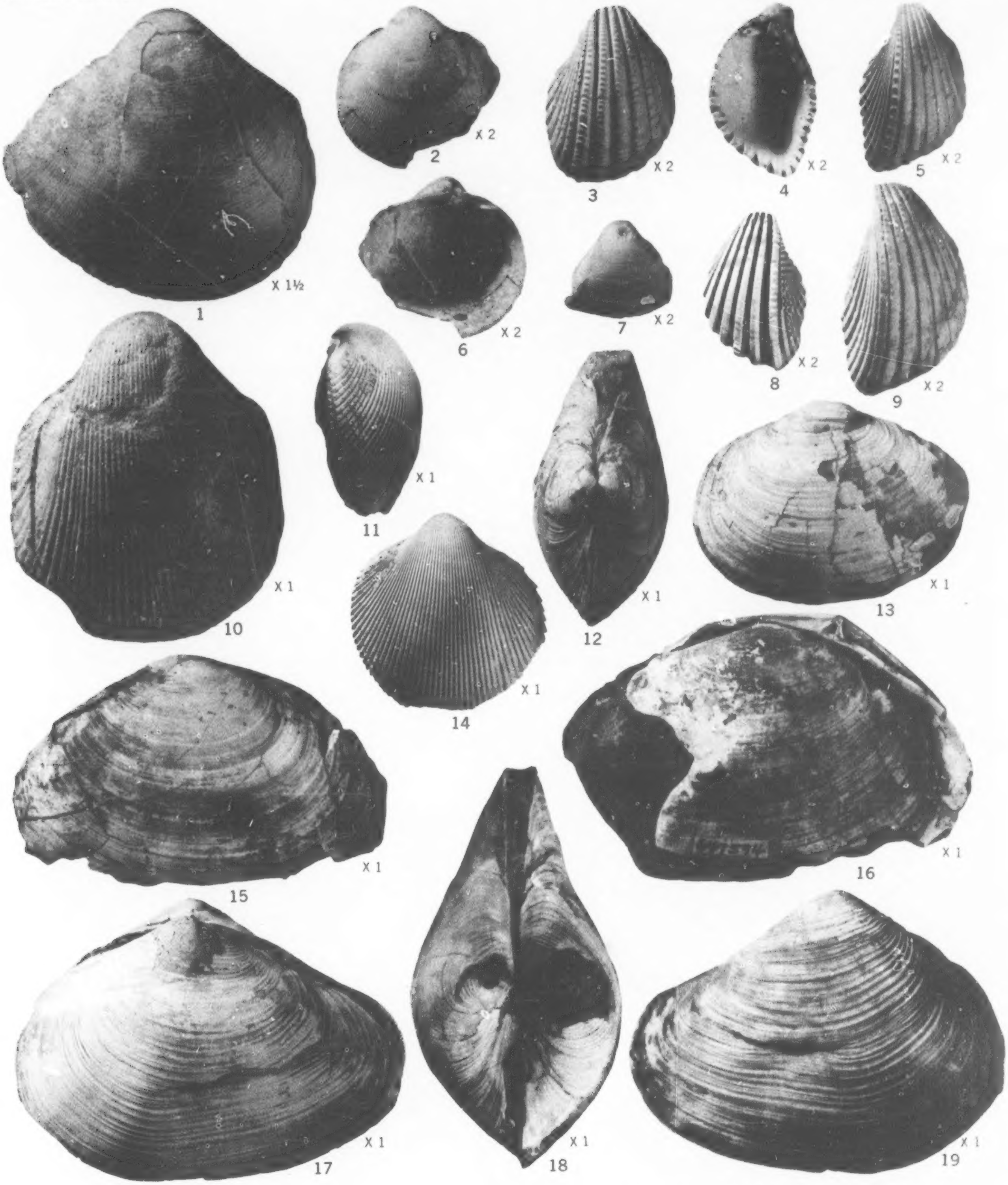
Type, articulated specimen. Length 74 mm. Locality 170a. USNM 647594.

- 15. Right valve.
- 16. Left valve and hinge of right valve.

17-19. *Raeta undulata* (Gould) (p. 653).

Articulated specimen. Length 72 mm. Locality 182a. USNM 647522.

- 17. Right valve.
- 18. Umbonal view.
- 19. Left valve.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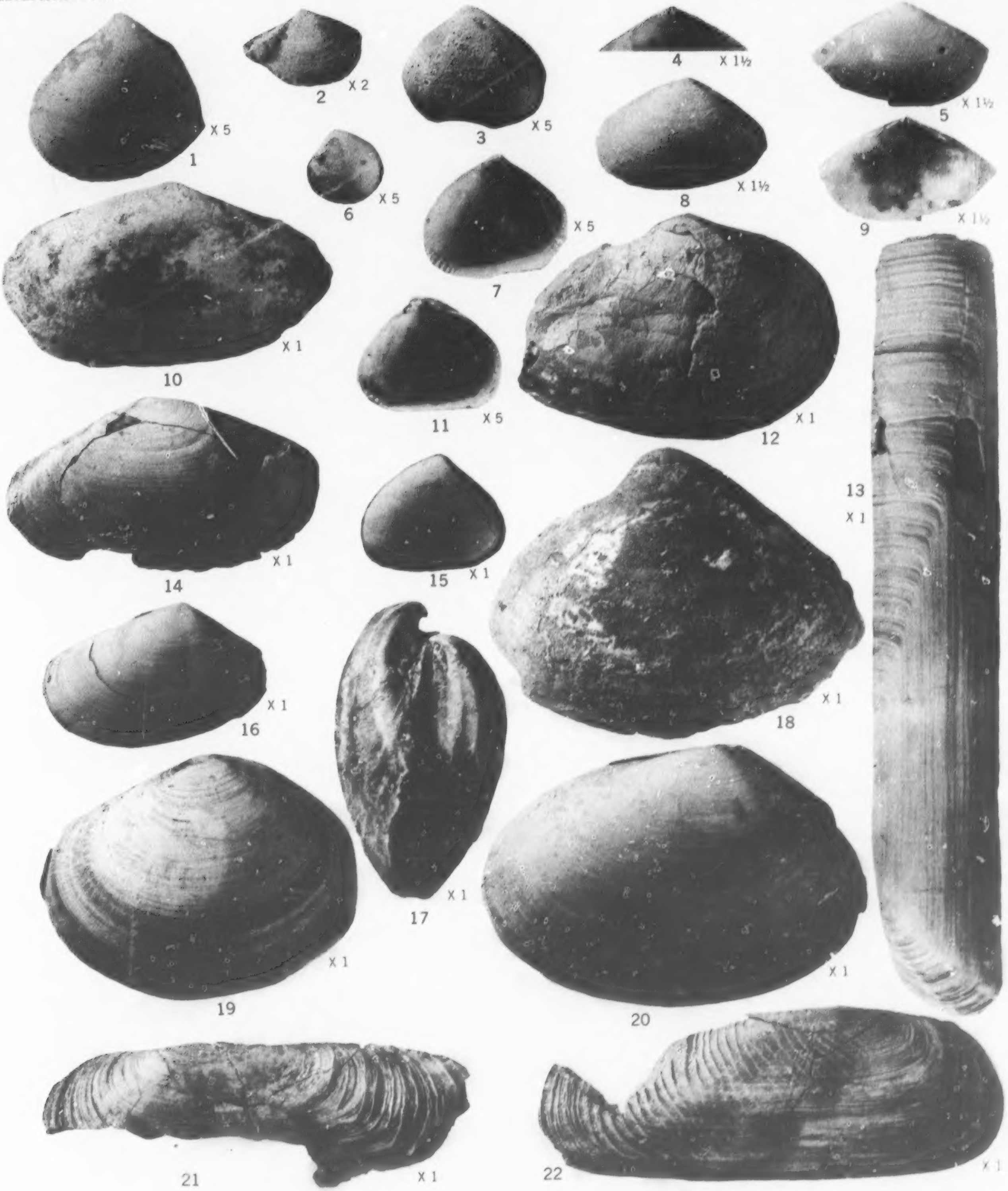
MIDDLE MIOCENE MOLLUSKS FROM GATUN FORMATION

PLATE 115

FIGURE 1. *Abra* (*Abra*) *lioica* (Dall)? (p. 678).
Left valve. Length (incomplete) 6.5 mm. Locality 173a. USNM 135595.
2. *Tellina* (*Merisca*) *cristallina* Spengler (p. 659).
Internal mold of right valve. Length 10 mm. Locality 165. USNM 647543.
3, 7, 11, 15. *Temblornia virgata* (Gardner) (p. 626).
3, 7. Left valve. Length 5.5 mm. Locality 136a. USNM 647371.
11, 15. Right valve. Length 5.5 mm. Locality 136a. USNM 647370.
4, 5, 8, 9. *Tellina* (*Eurytellina*) *punicea* Born (p. 661).
4, 8. Left valve. Length 21.2 mm. Locality 136. USNM 647550.
5, 9. Right valve. Length (incomplete) 22.1 mm. Locality 138c. USNM 647549.
6. *Timothynus capuloides* (Gabb) (p. 626).
Left valve. Length 2.8 mm. Locality 159d. USNM 647369.
10, 14, 16. *Psammacoma gatunensis* (Toula) (p. 668).
10. Left valve of internal mold of articulated specimen. Length 60.5 mm. Locality 136a. USNM 647591.
14. Right valve. Length 57.5 mm. Locality 139c. USNM 647590.
16. Left valve of articulated specimen. Length 40.5 mm. Locality 177e. USNM 647592.
12. *Sanguinolaria* (*Sanguinolaria*) aff. *S. tellinoides* A. Adams (p. 673).
Right valve. Length (incomplete) 58 mm. Locality 138f. USNM 647604.
13. *Solen* (*Solena*) *obliquus rudis* (C. B. Adams) (p. 655).
Left valve of articulated specimen. Length 153 mm. Locality 139e. USNM 647531.
17, 18. *Mactrellona alata* (Spengler) (p. 649).
Internal mold of articulated specimen. Length (almost complete) 68.7 mm. Locality 143. USNM 647514.
19, 20. *Semele laevis costaricensis* Olsson (p. 677).
19. Left valve of articulated specimen. Length 57.6 mm. Locality 138i. USNM 647616.
20. Left valve of articulated specimen. Length 69.7 mm. Locality 139g. USNM 647617.
21, 22. *Solecurtus broggii gatunensis* Toula (p. 674).
21. Left valve. Length 79.8 mm. Locality 152. USNM 647606.
22. Right valve. Length 87.3 mm. Locality 182a. USNM 647607.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MIDDLE MIOCENE MOLLUSKS FROM GATUN FORMATION

PLATE 116

FIGURES 1, 2. *Divaricella* cf. *D. comis* Olsson (p. 624).
1. Right valve of articulated specimen. Length 10.4 mm. Locality 139g. USNM 647359.
2. Umbonal view.

3, 4. 8. *Crassinella martinicensis* (d'Orbigny)? (p. 634).
3. Left valve. Length 3.9 mm. Locality 147g. USSNM 647428.
4. Left valve. Length 4.1 mm. Locality 147b. USNNM 647427.
8. Left valve. Length 2.4 mm. Locality 138c. USNM 647429.

5, 6, 11, 12. *Tellina* (*Phyllodina*) *lepidota* Dall (p. 657).
5. Right valve., Length 10.7 mm. Locality 159d. USNM 647541.
11. Reproduction of Dall's drawing of type.
6, 12. Right valve. Length 21 mm. Locality 157. USNM 647574.

7. *Eucrassatella* (*Hybolophus*) *elassa* Woodring, n. sp. (p. 633).
Type, left valve of articulated specimen. Length 43 mm. Locality 138a. USNM 647424.

9, 17. *Laevicardium laevigatum* (Linné) (p. 647).
Left valve. Length 21.8 mm. Locality 155. USNM 647511.

10, 13. *Parastarte psila* Woodring, n. sp. (p. 708).
Type, right valve. Length 1.85 mm. Locality 138c. USNM 647743.

14. *Eucrassatella* (*Eucrassatella*) sp. (p. 633).
Left valve. Length 27.5 mm. Locality 155b. USNM 647423.

15, 16. *Trachycardium* (*Dallocardia*) *baiterum* Woodring, n. sp. (p. 639).
15. Type, left valve. Length 27.2 mm. Locality 139c. USNM 647474.
16. Paratype, right valve. Length 23 mm. Locality 139c. USNM 647475.

18, 22. *Tellidora cristata* (Récluz) (p. 665).
Left valve. Length 39.7 mm. Locality 159d. USNM 647582.

19, 20. *Donax carinatus palaius* Woodring, n. subsp. (p. 671).
Type, left valve. Length 24.5 mm. Locality 161c. USNM 647599.
20. Posterior part.

21. *Eucrassatella* (*Hybolophus*) *venezuelana* (F. Hodson) (p. 634).
Umbonal view of articulated specimen. Length 45.3 mm. Locality 155. USNM 647426.

23. *Harvella elegans elegans* (Sowerby) (p. 652).
Left valve of articulated specimen. Length 48.3 mm. Locality 136. USNM 647518.

24. *Mulinia* aff. *M. cleryana* (d'Orbigny) (p. 650).
Left valve. Length 31.5 mm. Locality 161c. USNM 647516.

25. *Trachycardium* (*Phlogocardia*) *stiriatum* (Brown and Pilsbry) (p. 640).
Left valve. Length 32.2 mm. Locality 155b. USNM 647472.

26. *Dinocardium* cf. *D. cabezai* (Gardner) (p. 647).
Corroded right valve. Length (almost complete) 41.5 mm. Locality 160. USNM 647510.

27, 28. *Trachycardium* (*Dallocardia*) *dominicense hadratatum* Woodring, n. subsp. (p. 639).
27. Type, right valve of articulated specimen. Length (incomplete) 57 mm. Locality 182a. USNM 647469.
28. Paratype. Left valve of articulated specimen. Length (incomplete) 57 mm. Locality 185. USNM 647470.

29, 30. *Trachycardium* (*Mexicardia*) *dominicanum costaricanum* (Olsson) (p. 641).
29. Left valve of articulated specimen. Anterior ribs noded. Length 19 mm. Locality 136. USNM 647477.
30. Left valve. Anterior ribs smooth. Length 21.5 mm. Locality 155a. USNM 647476.

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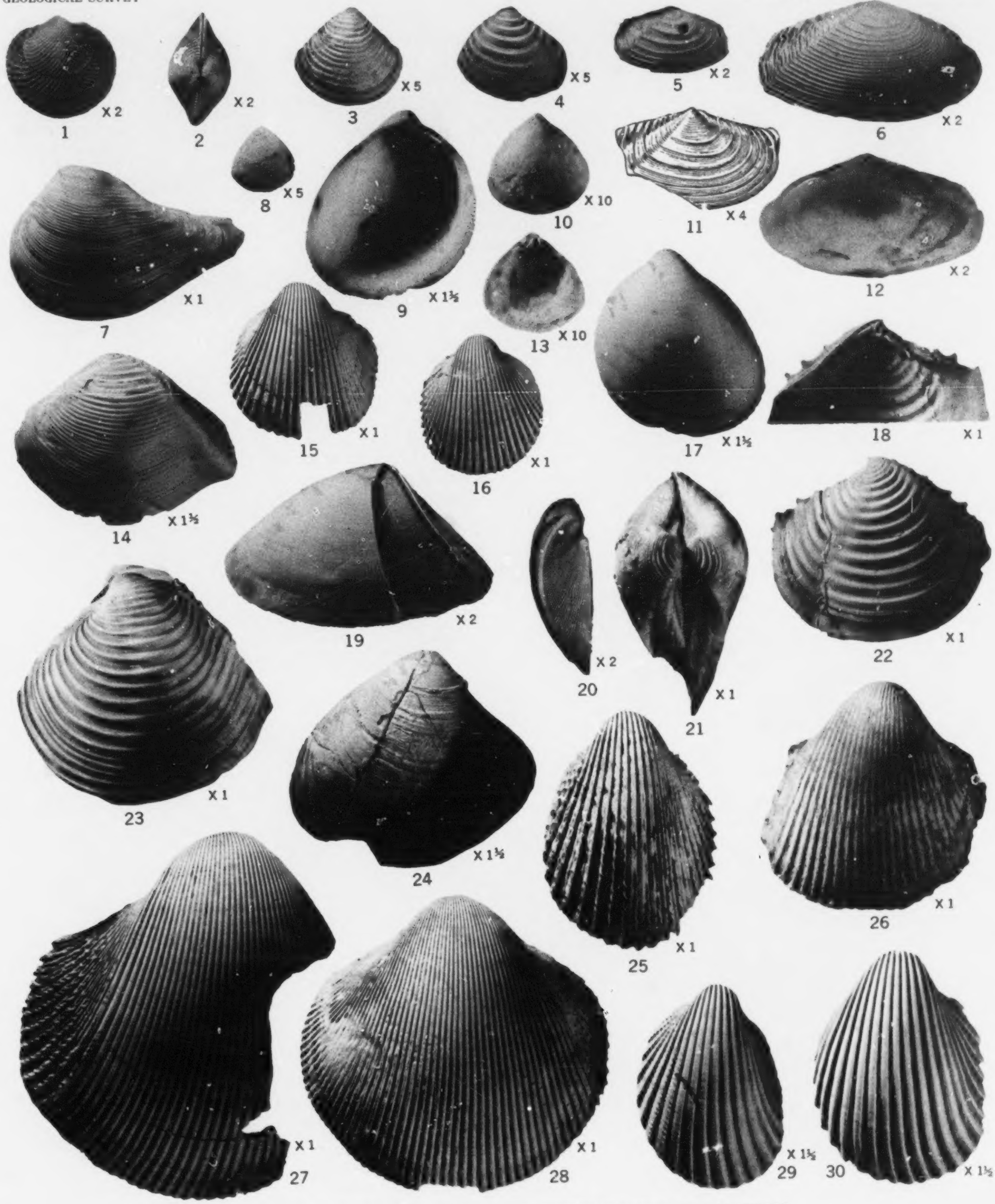
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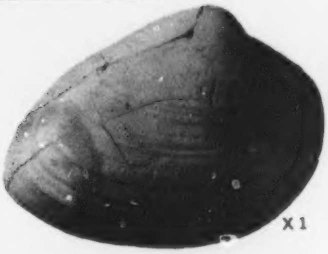
MIDDLE MIOCENE MOLLUSKS FROM GATUN FORMATION

PLATE 117

FIGURE

- 1\. *Macrocallista (Paradione) maculata* (Linné) (p. 689).
  - Right valve. Length 49.6 mm. Locality 138. USNM 647698.
- 2, 9, 10. *Lamelliconcha cora* (Brown and Pilsbry) (p. 688).
  - 2\. Right valve of articulated specimen. Length 34 mm. Locality 138h. USNM 647692.
  - 9, 10. Left valve. Length 34 mm. Locality 182. USNM 647693.
- 3, 4, 6, 7. *Alveinus rotundus* Dall (p. 678).
  - 3, 6. Right valve. Length 1.6 mm. Locality 138g. USNM 647622.
  - 4, 7. Left valve. Length 1.5 mm. Locality 138g. USNM 647623.
- 5\. *Transennella cola* Woodring, n. sp. (p. 684).
  - Type, left valve. Length 4.6 mm. Locality 159d. USNM 647646.
- 8\. *Tagelus (Mesopleura) divisus* (Spengler)? (p. 675).
  - Right valve. Length 22 mm. Locality 138d. USNM 647609.
- 11, 13. *Pleuromeris* aff. *P. acaris* (Dall) (p. 629).
  - Left valve. Length 2.1 mm. Locality 169. USNM 647383.
- 12\. *Tivela (Tivela) mactroides* (Born), small form (p. 683).
  - Left valve. Length 30 mm. Locality 164. USNM 647644.
- 14, 18. *Eucrassatella (Hybolophus) elassa* Woodring, n. sp. (p. 633).
  - 14\. Right valve of articulated specimen. Length 35.8 mm. Locality 138c. USNM 647425.
  - 18\. Umbonal view.
- 15\. *Ventricolaria* sp. (p. 682).
  - Right valve. Length (almost complete) 49.7 mm. Locality 147h. USNM 647640.
- 16, 17. *Tellina (Eurytellina) nitens* C. B. Adams (p. 662).
  - 16\. Right valve. Length 21.9 mm. Locality 159d. USNM 647552.
  - 17\. Right valve. Length 23 mm. Locality 159d. USNM 647551.
- 19\. *Eucrassatella (Hybolophus) venezuelana* (F. Hodson) (p. 634).
  - Right valve of articulated specimen. Length 45.3 mm. Locality 155. USNM 647426.
- 20\. *Semele laevis costaricensis* Olsson (p. 677).
  - Right valve of articulated specimen. Length 57.4 mm. Locality 138i. USNM 647615.
- 21, 25. *Strigilla (Strigilla) carnaria* (Linné) (p. 666).
  - 21\. Left valve. Length 16.3 mm. Locality 155c. USNM 647586.
  - 25\. Right valve. Length 16.6 mm. Locality 156. USNM 647585.
- 22, 23. *Tellina (Merisca) aequistriata* Say (p. 659).
  - Left valve. Length (incomplete) 9.9 mm. Locality 139c. USNM 647544.
- 24, 27. *Tellina (Eurytellina) angulosa costaricana* Olsson (p. 663).
  - Right valve. Length 45 mm. Locality 159d. USNM 647573.
- 26, 29, 30. *Tellina (Miratellina) anaxia* Woodring, n. sp. (p. 660).
  - Type. Articulated specimen. Length 40.7 mm. Locality 136a. USNM 647545.
  - 26\. Umbonal view.
  - 29\. Left valve.
  - 30\. Right valve.
- 28\. *Semele* cf. *S. perlamellosa* Heilprin (p. 677).
  - Left valve of articulated internal mold. Length 45.8 mm. Locality 160. USNM 647614.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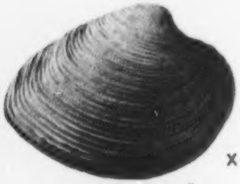
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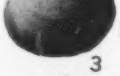
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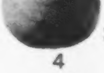
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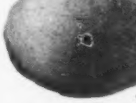
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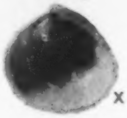
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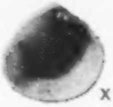
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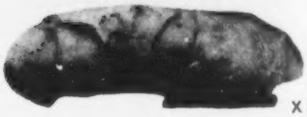
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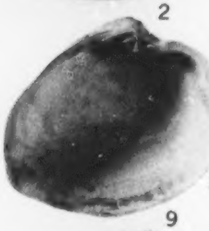
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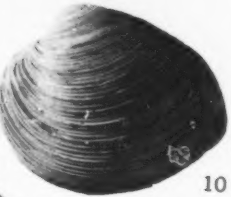
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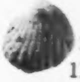
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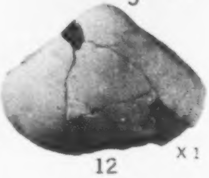
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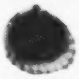
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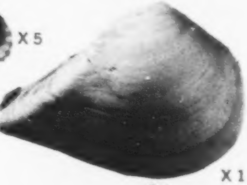
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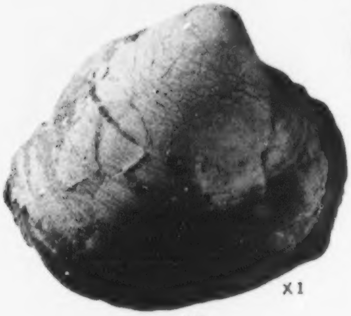
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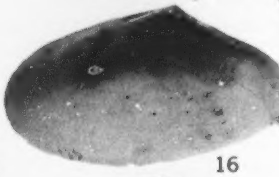
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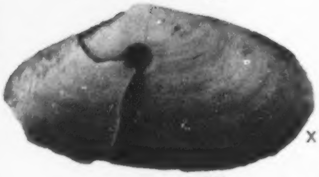
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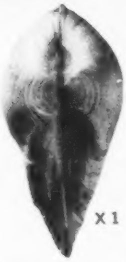
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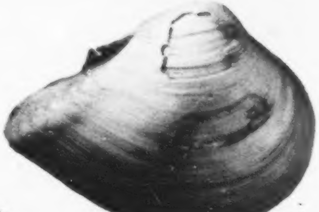
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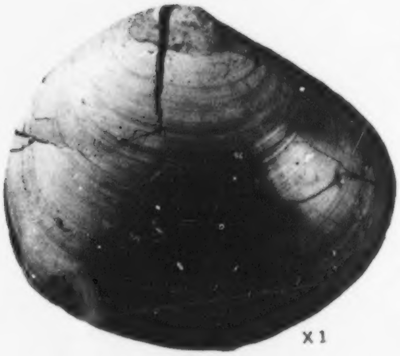
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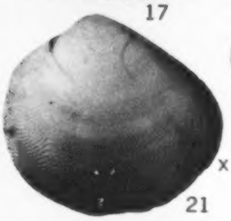
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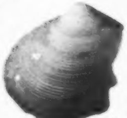
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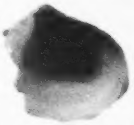
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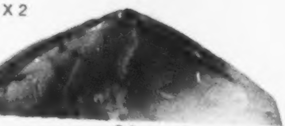
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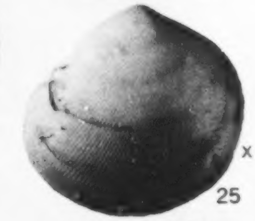
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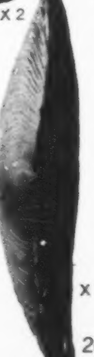
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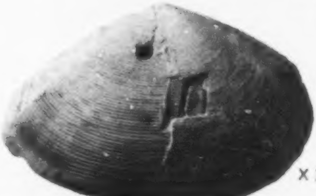
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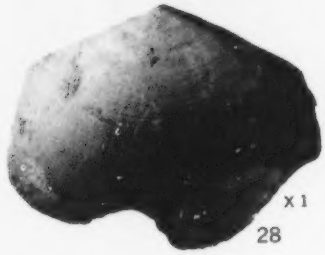
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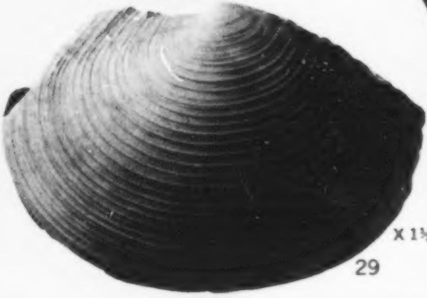
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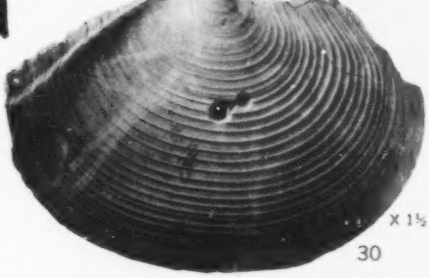
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MIDDLE MIOCENE MOLLUSKS FROM GATUN FORMATION

PLATE 118

FIGURES

1, 3–7. *Agriopoma* (*Pitarella*) *gatunensis* (Dall) (p. 692).

1. Hinge of left valve. Dorsal length 37.7 mm. Locality 138c. USNM 647635.
3. Right hinge. Dorsal length shown 17.5 mm. Locality 155c. USNM 647636.
4. Left valve of articulated specimen. Length 37.7 mm. Locality 175. USNM 647634.
5. Type of *Callocardia multifilosa*, right valve. Length 38.7 mm. Locality 177f. USNM 6392a.
6. Type, left valve. Length (incomplete) 36 mm. Locality 158. USNM 135249.
7. Left valve. Length 47.3 mm. Locality 139h. USNM 647633.

2. *Rupellaria typica* (Jonas) (p. 709).

Left valve. Length (almost complete) 22.5 mm. Locality 175. USNM 647745.

8, 12. *Hysteroconcha rosea vanwinkleae* (Olsson) (p. 687).

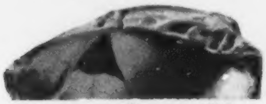
8. Right valve of articulated specimen. Length 42.9 mm. Locality 155. USNM 647694.
12. Immature right valve. Length 31.3 mm. Locality 155c. USNM 647739.

9, 14. *Dosinia* (*Dosinia*) *delicatissima* Brown and Pilsbry (p. 694).

9. Right valve of articulated specimen. Length 55.7 mm. Locality 159b. USNM 647704.
14. Left valve. Length (almost complete) 65 mm. Locality 182a. USNM 647705.

10, 11, 13, 15. *Clementia* (*Clementia*) *dariena dariena* (Conrad) (p. 699).

10. Right valve. Length (practically complete) 64.7 mm. Locality 153. USNM 647720.
11. Right valve of articulated specimen. Length 60.5 mm. Locality 138c. USNM 647719.
13. Left hinge. Dorsal length shown 36 mm. Locality 138c. USNM 647722.
15. Left valve and right hinge. Dorsal length of right valve shown 12 mm. Left valve length (incomplete) 38 mm. Locality 138c. USNM 647721.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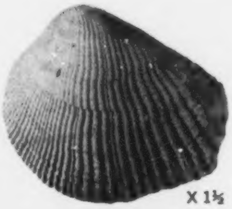
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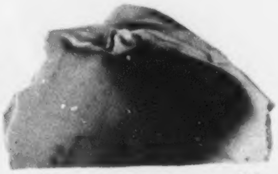
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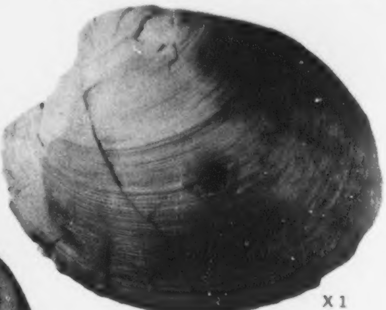
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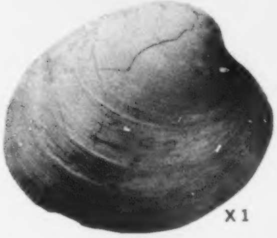
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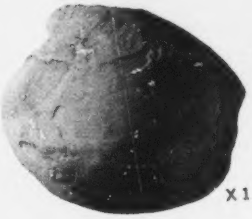
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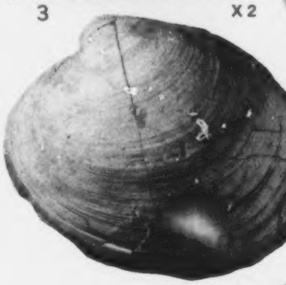
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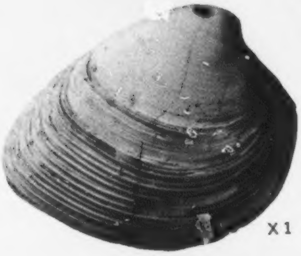
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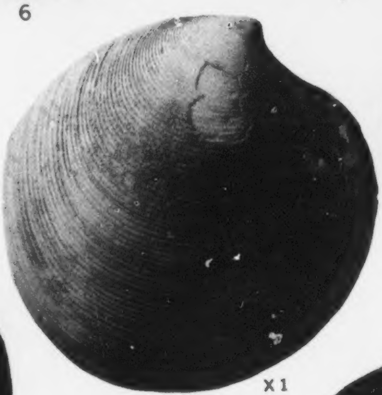
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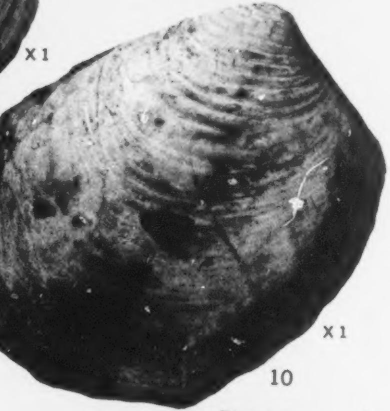
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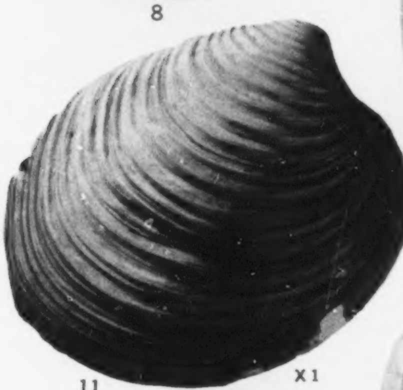
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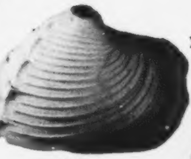
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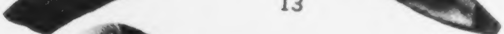
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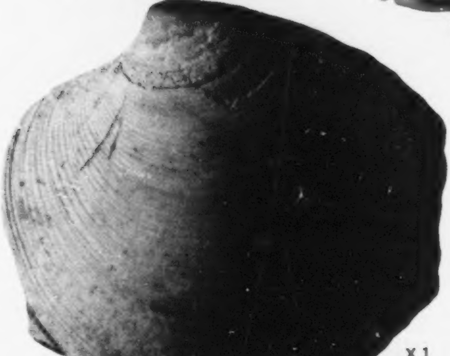
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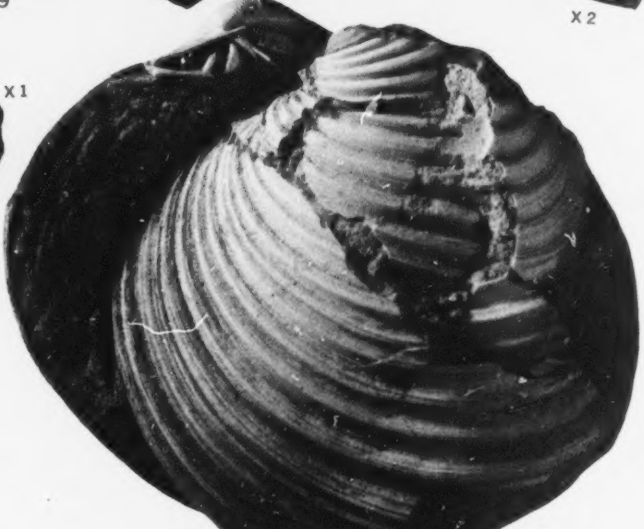
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MIDDLE MIOCENE MOLLUSKS FROM GATUN FORMATION

PLATE 119

FIGURES 1, 7. *Lirophora* (*Lirophora*) *falconensis* (H. K. Hodson) (p. 703).
- 1. Right valve. Length 27.7 mm. Locality 138c. USNM 647732.
- 7. Right valve. Length (practically complete) 26.6 mm. Locality 139b. USNM 647734.

2. *Nioche* (*Antinioche*) *dolicha* Woodring, n. sp. (p. 707).
- Type, left valve. Length 41.7 mm. Locality 138d. USNM 647629.

3, 8–10. *Gouldia costaricensis* (Olsson) (p. 682).
- 3, 8. Left valve. Length 3.1 mm. Locality 147b. USNM 647642.
- 9, 10. Right valve. Length 2.8 mm. Locality 147b. USNM 647641.

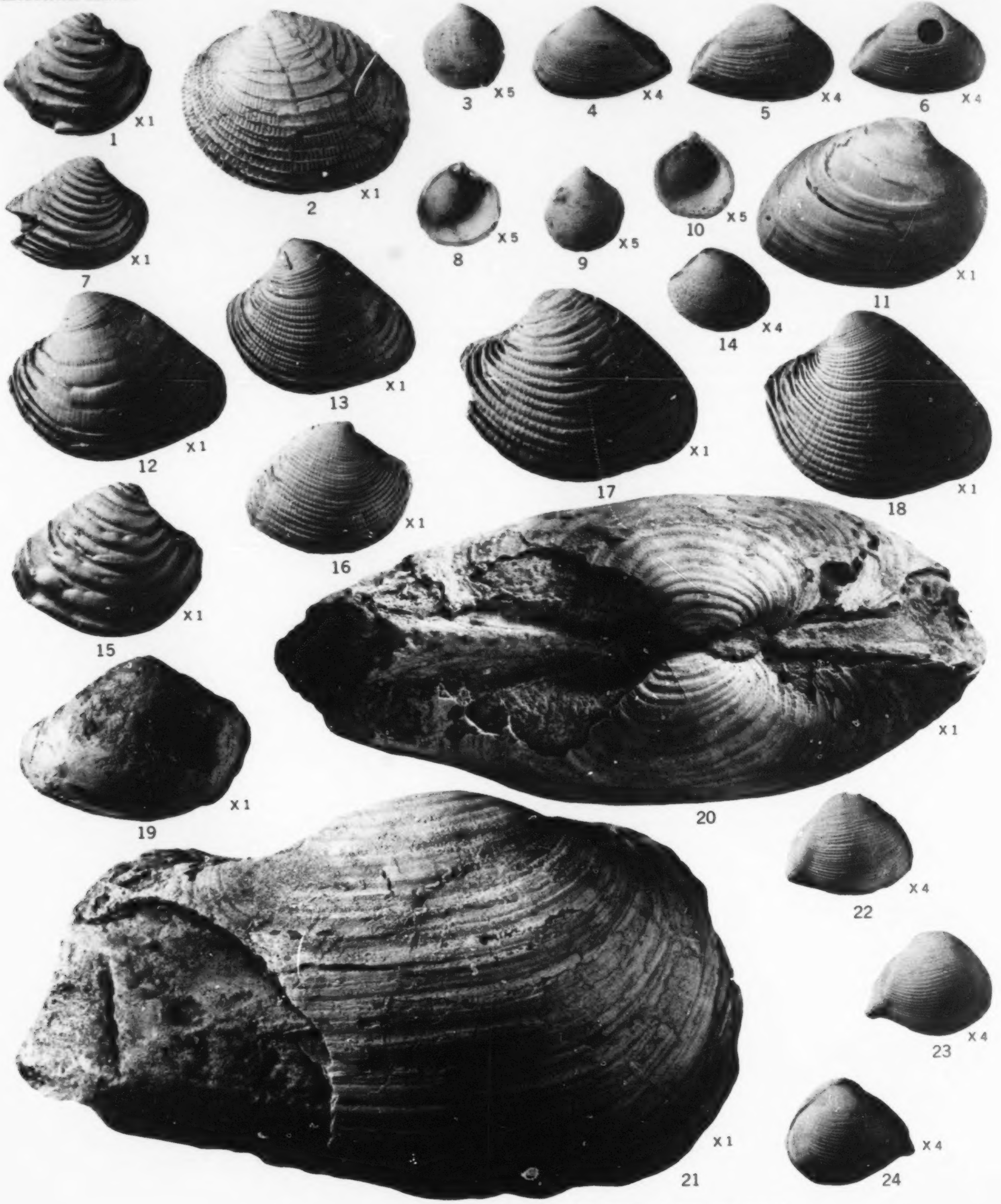
4–6. *Caryocorbula oropendula dolicha* Woodring, n. subsp. (p. 712).
- 4, 6. Paratype, articulated specimen. Left valve fig. 4). Length 6 mm. Right valve (fig. 6). Length 6.6 mm. Locality 185. USNM 647754.
- 5. Type, right valve. Length 6.9 mm. Locality 185. USNM 647753.

11, 14. *Costacallista leiotera* Woodring, n. sp. (p. 692).
- 11. Type, right valve. Length 43 mm. Locality 159d. USNM 647700.
- 14. Immature left valve. Length 4.7 mm. Locality 159d. USNM 647701.

12, 13, 15–19. *Lirophora* (*Panchione*) *mactropsis* (Conrad) (p. 704).
- 12. Left valve. Length 39.6 mm. Locality 139e. USNM 647735.
- 13. Left valve. Length 35 mm. Locality 139h. USNM 647738.
- 15. Right valve. Length 34.8 mm. Locality 138e. USNM 647733.
- 16. Lectotype of *L. ulocyma holocyma*. Right valve. Length 30 mm. Acad. Nat. Sci. Philadelphia. Gatun Locks excavation.
- 17. Left valve. Length 45.0 mm. Locality 183. USNM 647736.
- 18. Left valve. Length 43 mm. Locality 155a. USNM 647737.
- 19. Type. Articulated specimen, devoid of sculpture. Length 42.3 mm. Pre-canal Gatun. USNM 1843.

20, 21. *Panopea parawhitfieldi* (Gardner) (p. 718).
- Articulated specimen. Length (incomplete) 120 mm. Locality 159d. USNM 647794.
- 20. Umbonal view.
- 21. Right valve.

22–24. *Caryocorbula oropendula stena* Woodring, n. subsp. (p. 711).
- 22. Type, right valve. Length 6.1 mm. Locality 147b. USNM 647751.
- 23. Paratype, articulated specimen. Length 5.6 mm. Locality 155b. USNM 647752.
- 24. Left valve of paratype. Length 5.5 mm. Locality 155b. USNM 647752.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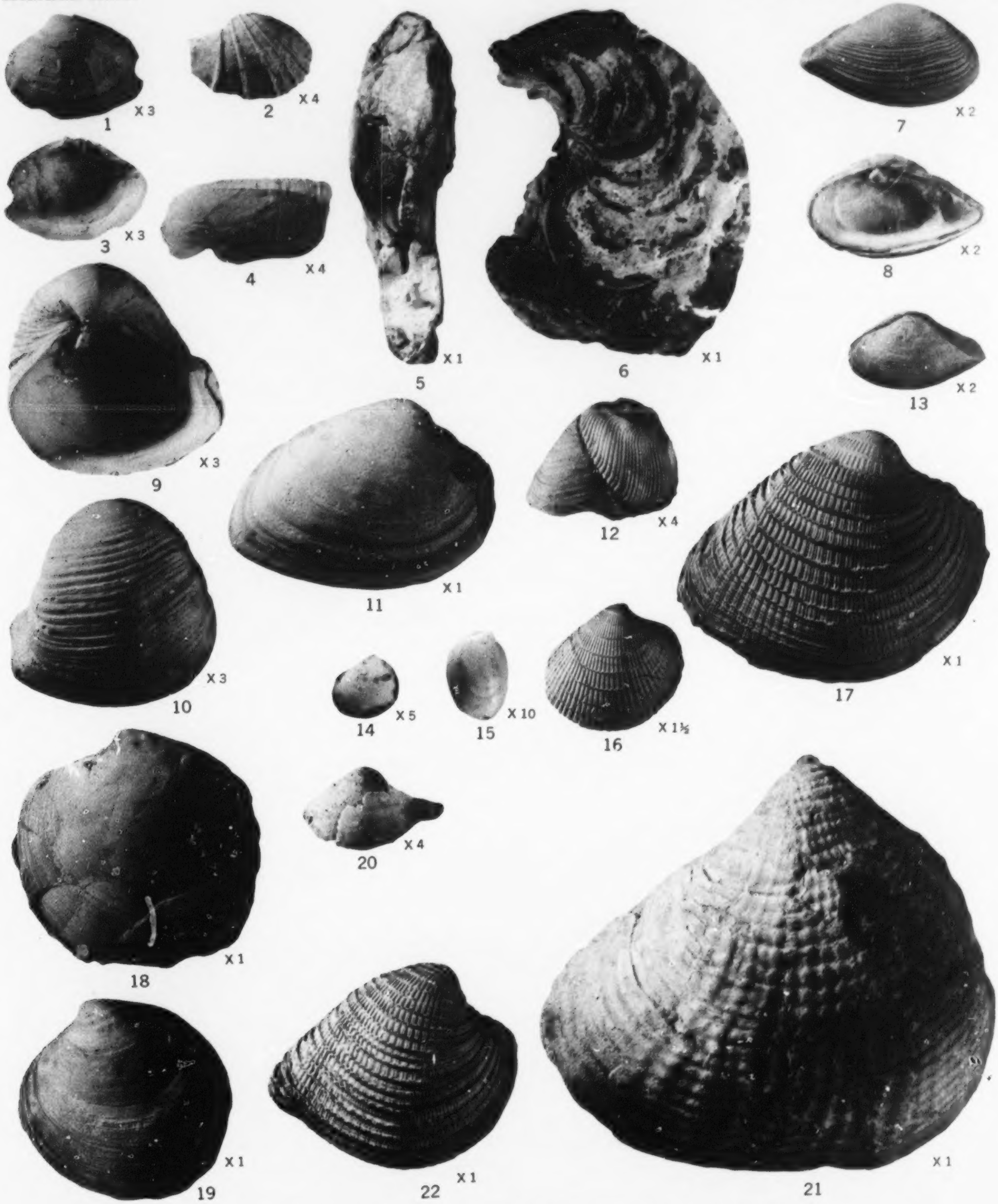
21 X1
22 X4
23 X4
24 X4

MIDDLE MIOCENE MOLLUSKS FROM GATUN FORMATION

PLATE 120

FIGURES 1, 3, 9, 10. *Varicorbula islatrinitatis* (Maury) (p. 717).
1, 3. Left valve. Length 8.9 mm. Locality 144d. USNM 647769.
9, 10. Right valve. Length 13.3 mm. Locality 155b. USNM 647768.
2. *Cardiomya mansfieldi* (Olsson and Harbison) (p. 723).
Right valve. Length 5.8 mm. Locality 159d. USNM 647806.
4. *Pandora* (*Pandorella*) *inconspicua* Gabb (p. 721).
Left valve. Length 8 mm. Locality 159d. USNM 647800.
5, 6. *Aturia curvilineata* Miller and Thompson? (p. 725).
Two views. Greatest preserved diameter 61 mm. Locality 139a. USNM 647810.
7, 8, 13. *Caryocorbula prenasuta* Olsson (p. 712).
7, 8. Right valve. Length 16.8 mm. Locality 138d. USNM 647756.
13. Left valve of articulated specimen. Length 12.9 mm. Locality 136. USNM 647755.
11. *Macrocallista* (*Paradione*) *maculata* (Linné) (p. 689).
Right valve. Length 48.6 mm. Locality 138e. USNM 647699.
12. *Martesia sanctipauli* Maury (p. 718).
Right valve. Length 7.5 mm. Locality 161c. USNM 647795.
14. *Diplodonta* (*Diplodonta*) cf. *D. minor* Dall (p. 625).
Left valve. Length 2.5 mm. Locality 159d. USNM 647638.
15. *Nucinella* cf. *N. woodii* (Dall) (p. 723).
Left valve of articulated specimen. Length 1.1 mm. Locality 147b. USNM 647372.
16, 17, 22. *Chione* (*Chionopsis*) *tegulum* Brown and Pilsbry (p. 702).
16. Immature right valve. Length 17.5 mm. Locality 136a. USNM 647729.
17. Right valve. Length 59 mm. Locality 182a. USNM 647730.
22. Right valve of articulated specimen. Length 46 mm. Locality 138h. USNM 647728.
18, 19. *Cyclinella cyclica* (Guppy) (p. 696).
18. Lectotype of *C. gatunensis* Dall, articulated specimen. Length 44.8 mm. Locality 158, Gatun. USNM 135257.
19. Lectotype of *C. cyclica*, articualetd specimen. Length 39.2 mm. Locality Manzanilla, Trinidad. USNM 115541.
20. *Cuspidaria* cf. *C. obesa* Lovén (p. 722).
Left valve. Length 5.5 mm. Locality 177d. USNM 647804.
21. *Pholadomya falconensis* F. and H. Hodson (p. 720).
Right valve of articulated specimen. Length 81 mm. Locality 160. USNM 647799.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14 X 5
15 X 10
16 X 1½
18 X 1
20 X 4
19 X 1
22 X 1
21 X 1

MIDDLE MIOCENE MOLLUSKS FROM GATUN FORMATION

PLATE 121

FIGURES 1, 2, 4–6. *Bothrocorbula (Hexacorbula) gatunensis* (Toula) (p. 714).
  1. Left valve, abnormal sculpture. Length 16.5 mm. Locality 150. USNM 647761.
  2, 6. Right valve of articulated specimen (fig. 2). Length 18.7 mm. Base of same specimen (fig. 6). Locality 138c. USNM 647759.
  4, 5. Right valve. Length 20.7 mm. Locality 138c. USNM 647760.

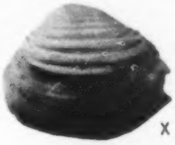
3, 10. *Flabellipecten gatunensis macdonaldi* (Olsson) (p. 585).
  3. Right valve. Length 100 mm. Locality 188d. USNM 646991.
  10. Right valve. Length 100 mm. Locality 188d. USNM 646990.

7. *Cyathodonta gatunensis* (Toula) (p. 722).
  Left valve of articulated internal mold. Length (practically complete) 44.7 mm. Locality 159d. USNM 647803.

8. *Cyathodonta*? cf. *C.*? *dolicha* Woodring, n. sp. (p. 721).
  Right valve of articulated internal mold. Length 35.7 mm. Locality 139f. USNM 647802.

9. *Lucinoma tapeina* Woodring, n. sp. (p. 621).
  Type, left valve of articulated specimen. Length 25.8 mm. Locality 204. USNM 647747.

11, 12. *Anomia simplex* d'Orbigny (p. 604).
  11. Left valve. Length 26 mm. Locality 195. USNM 647253.
  12. Left valve. Length 30.7 mm. Locality 195. USNM 647252.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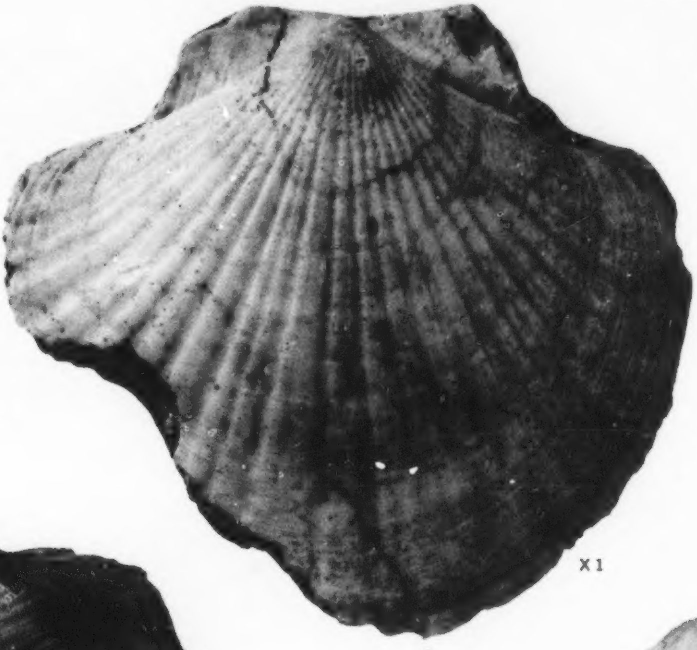
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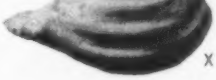
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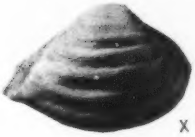
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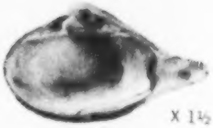
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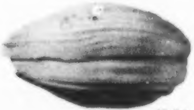
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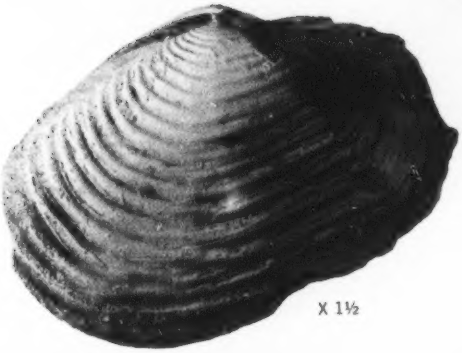
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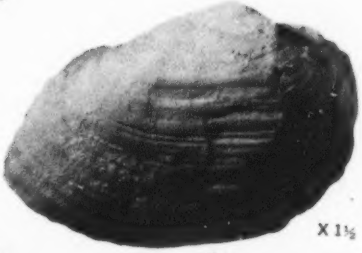
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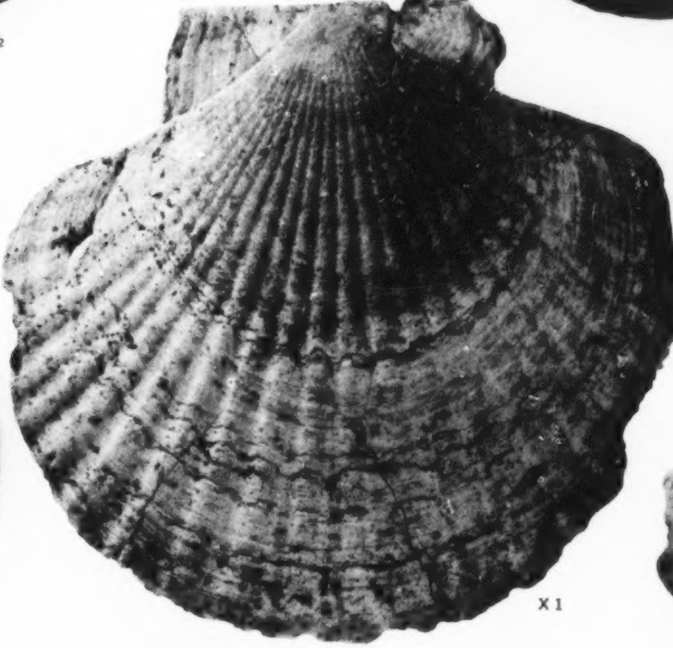
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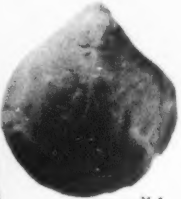
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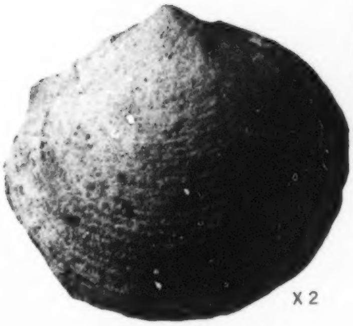
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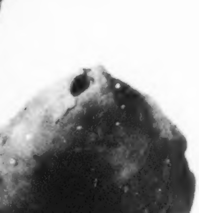
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12

MIDDLE MIOCENE MOLLUSKS FROM GATUN FORMATION AND LATE MIOCENE OR EARLY PLIOCENE MOLLUSKS FROM TORO LIMESTONE MEMBER OF CHAGRES SANDSTONE (FIGS. 3, 10, 11, 12) AND CHAGRES SANDSTONE PROPER (FIG. 9)

PLATE 122

FIGURE 1. *Tellina* (*Tellinella*) cf. *T. rovala* Olsson (p. 657).

Right valve. Length (incomplete) 32.9 mm. Locality 201. USNM 647537.

2, 3. *Amusium mimyum* Woodring, n. sp. (p. 587).

Small left valve. Length 47.5 mm. Locality 201. USNM 647136.

4-8, 11. *Pitar* (*Hyphantosoma*) *centangulatus* Brown and Pilsbry (p. 686).

4, 8. Left (fig. 4) and right (fig. 8) valves of articulated type. Length 38 mm. Locality Gatun Locks excavation. Acad. Nat. Sci. Philadelphia 1764.

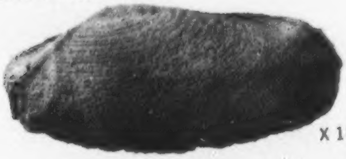
5. Left valve. Length 36.4 mm. Locality 139c. USNM 647686.

6, 7. Left valve. Length 40.7 mm. Locality 155b. USNM 647685.

11. Right valve. Length (incomplete) 36 mm. Locality 155b. USNM 647687.

9, 10. *Flabellipecten gatunensis tapeinus* Woodring, n. subsp. (p. 585).

Type. Right (fig. 9) and left (fig. 10) valves of articulated specimen. Length 96.5 mm. Locality 207. USNM 646992.



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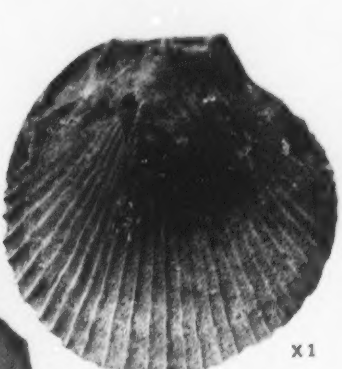

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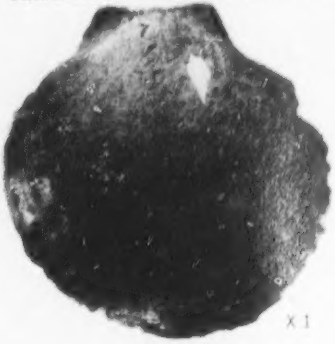

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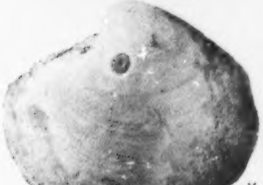

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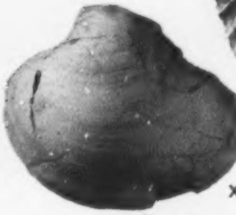

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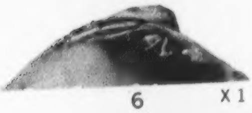

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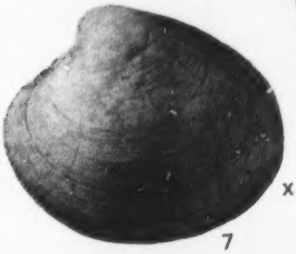

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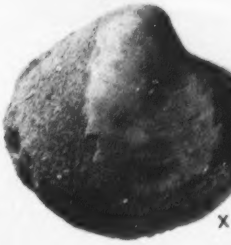

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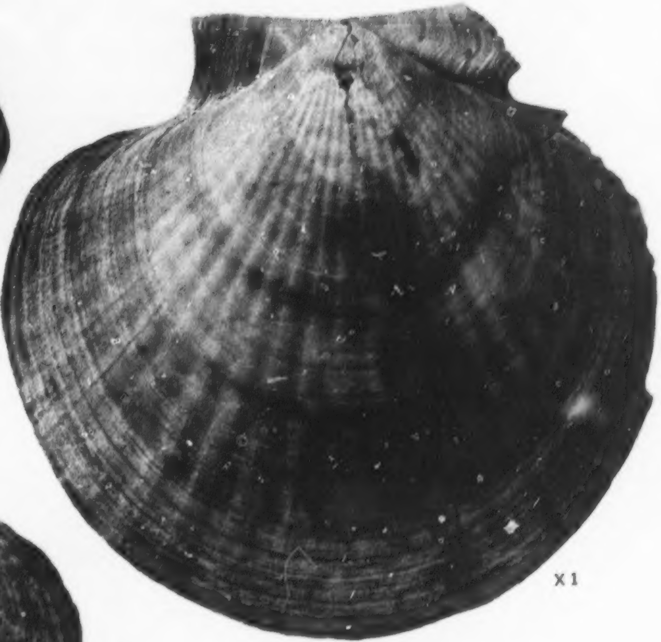

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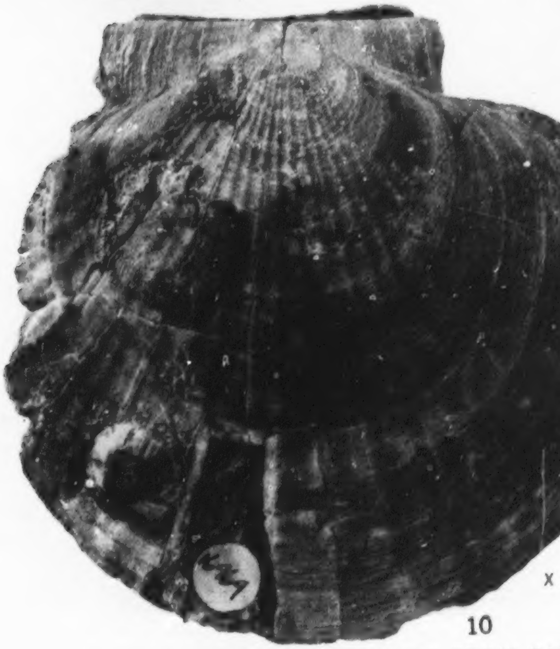

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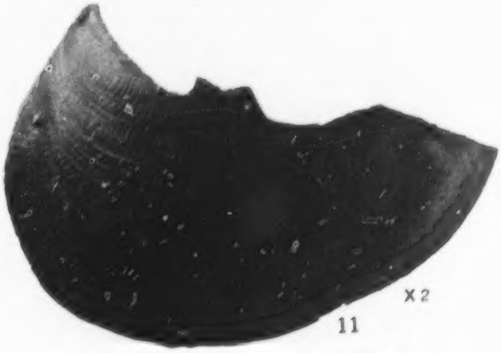


X 2

11

MIDDLE MIOCENE MOLLUSKS FROM GATUN FORMATION AND LATE MIOCENE OR EARLY PLIOCENE MOLLUSKS FROM CHAGRES SANDSTONE PROPER (FIGS. 1, 2, 3, 9, 10)

PLATE 123

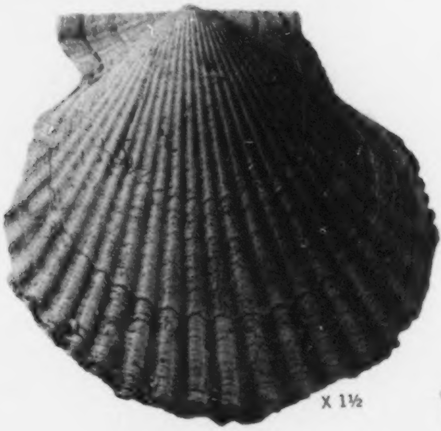
FIGURES 1, 2, 4. *Argopecten nerterus* Woodring, n. sp. (p. 597).
  1. Left valve. Length 42.8 mm. Locality 188. USNM 647132.
  2. Type, right valve. Length 46 mm. Locality 188. USNM 647131.
  4. Left valve. Length 39.5 mm. Locality 188. USNM 647133. Ribs slightly higher than usual.

3, 5. *Cyclinella cyclica* (Guppy) (p. 696).
  3. Left valve of articulated specimen. Length 46.3 mm. Locality 139e. USNM 647709.
  5. Right valve of articulated specimen. Length 51 mm. Locality 140. USNM 647710.

6. *Tellina* (*Angulus*) cf. *T.* (*A.*) *umbra* Dall (p. 665).
  Right valve. Length 12.2 mm. Locality 206. USNM 647581.

7. *Amusium toulae* (Brown and Pilsbry) (p. 588).
  Right valve. Length 90 mm. Locality 196. USNM 647198.

8. *Amusium mimyum* Woodring, n. sp. (p. 587).
  Type, right valve. Length 69.9 mm. Locality 206. USNM 647134.



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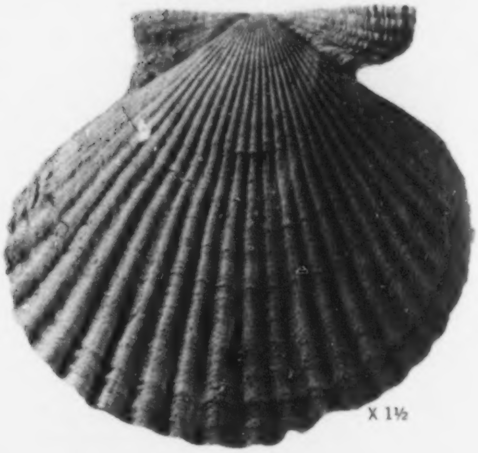

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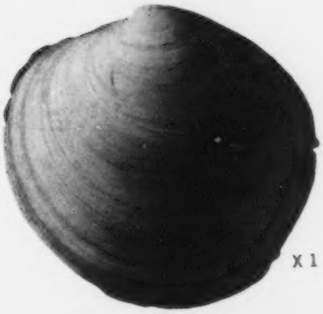

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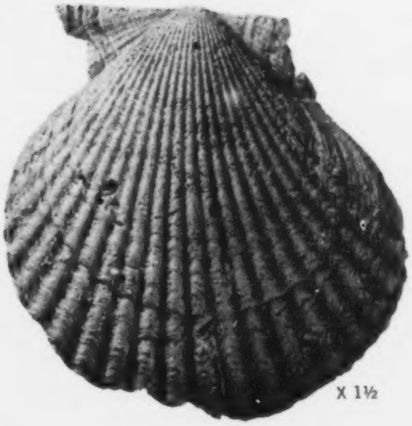

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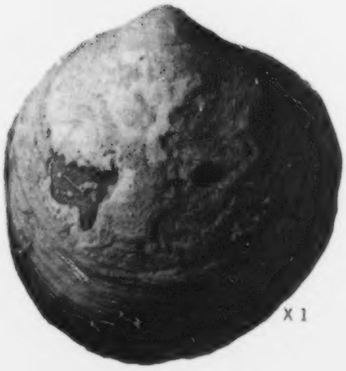

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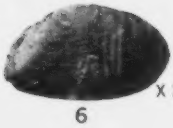

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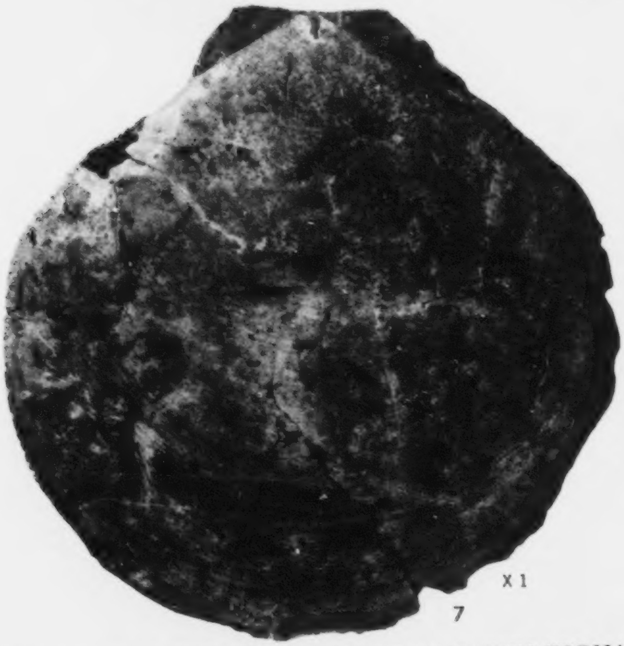

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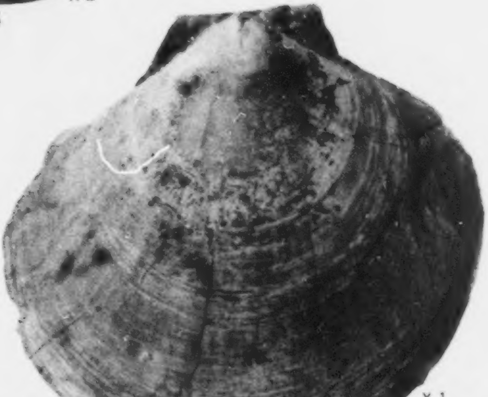


8

MIDDLE MIOCENE MOLLUSKS FROM GATUN FORMATION (FIGS. 3, 5) AND LATE MIOCENE OR EARLY PLIOCENE MOLLUSKS FROM TORO LIMESTONE MEMBER OF CHAGRES SANDSTONE (FIGS. 1, 2, 4) AND CHAGRES SANDSTONE PROPER (FIGS. 6, 7, 8)

PLATE 124

FIGURES 1, 9–11. *Cryptopecten cactaceus* (Dall) (p. 594).

- 1. Lectotype, immature right? valve. Length 28.3 mm. Locality 70 km. west of terminus of Ferrocarril de Tehuantepec, Vera Cruz, México. USNM 135058.
- 9. Left valve. Length 46.7 mm. Locality 206. USNM 647232. Outer crust partly preserved near ventral margin.
- 10. Right valve. Length 49.3 mm. Locality 206. USNM 647231. Outer crust effaced. Anterior edge of anterior auricle incomplete.
- 11. Outer crust of small area in ventral part of left valve shown in fig. 9.

2, 3. *Plicatula gibbosa* Lamarck, small form (p. 599).

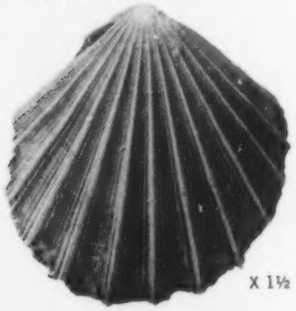
- 2. Right valve. Length 14 mm. Locality 196. USNM 647250.
- 3. Left? valve. Length 13.5 mm. Locality 196. USNM 647251.

4. *Amusium mimyum* Woodring, n. sp. (p. 587).

Small right valve. Length (almost complete) 46 mm. Locality 206. USNM 647135.

5–8. *Varicorbula disparilis* (d'Orbigny) small form (p. 716).

- 5. Left valve. Length 4.9 mm. Locality 147b. USNM 647766.
- 6. Narrow right valve. Length 4.9 mm. Locality 147b. USNM 647765.
- 7, 8. Wide right valve. Length 6.8 mm. Locality 147b. USNM 647764.



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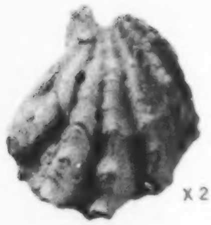

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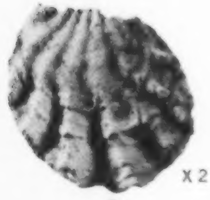

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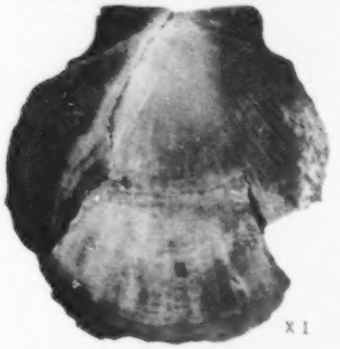

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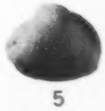

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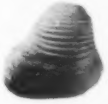

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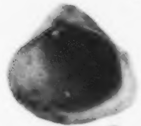

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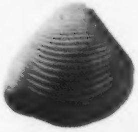

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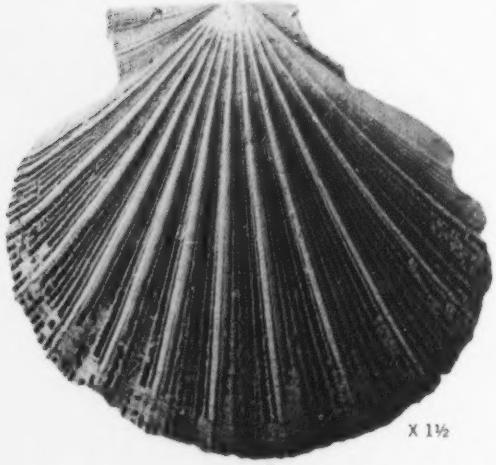

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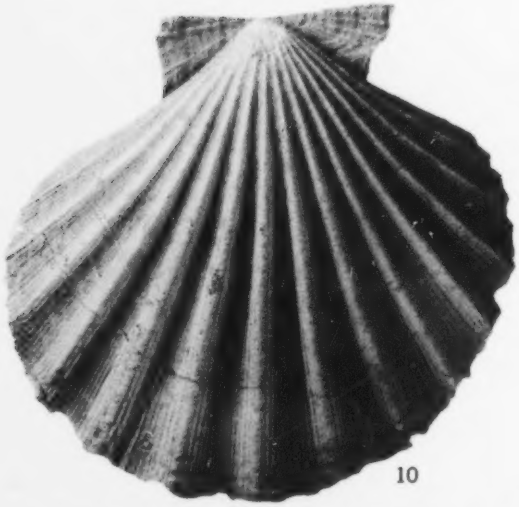

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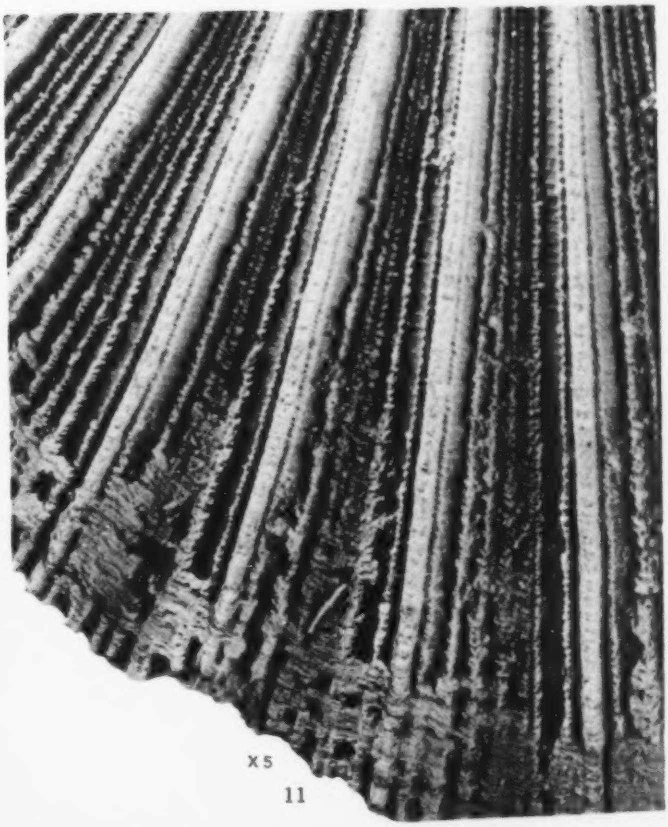

X 5

11

MIDDLE MIOCENE MOLLUSKS FROM GATUN FORMATION (FIGS. 5–8) AND LATE MIOCENE OR EARLY PLIOCENE MOLLUSKS FROM TORO LIMESTONE MEMBER OF CHAGRES SANDSTONE (FIGS. 2, 3), AND CHAGRES SANDSTONE PROPER (FIGS. 4, 9–11)

Geology and Paleontology of Canal Zone and Adjoining Parts of Panama

By W. P. WOODRING

GEOLOGICAL SURVEY PROFESSIONAL PAPER 306

U.S. DEPARTMENT OF THE INTERIOR
March 3, 1849

This volume was published
as separate chapters A-F

UNITED STATES DEPARTMENT OF THE INTERIOR

JAMES G. WATT, *Secretary*

GEOLOGICAL SURVEY

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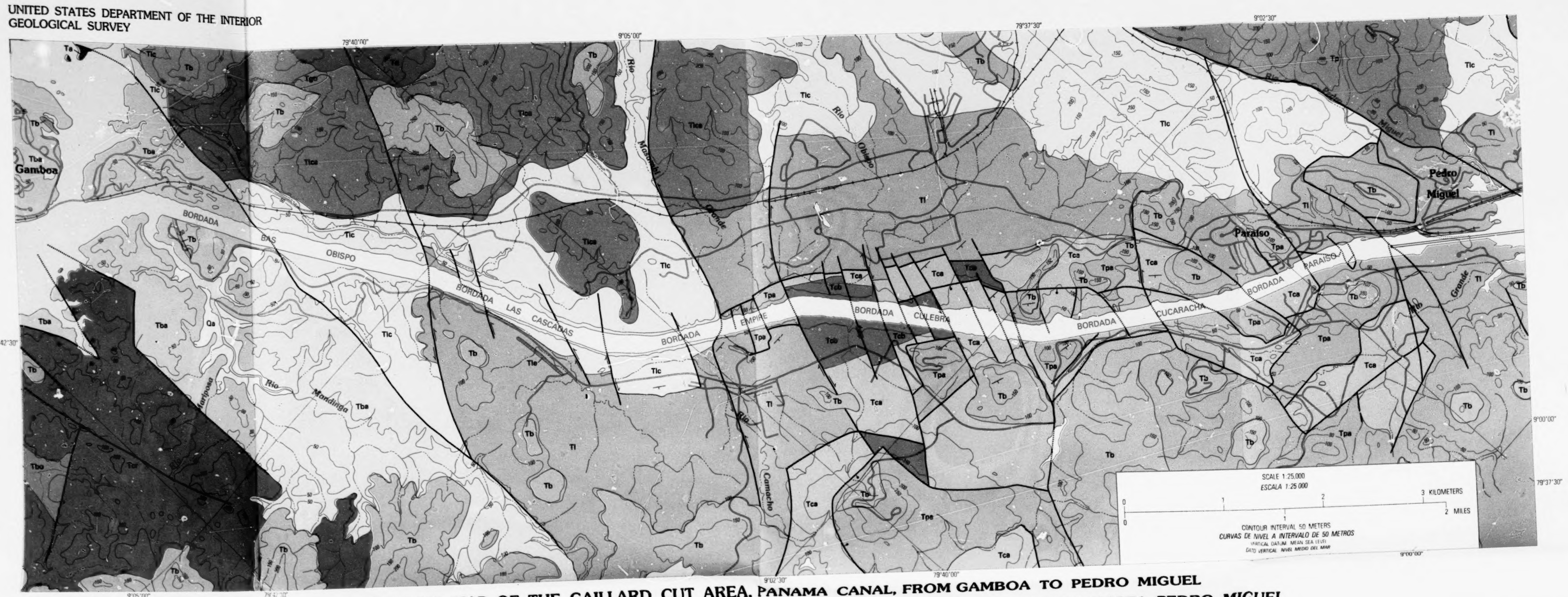
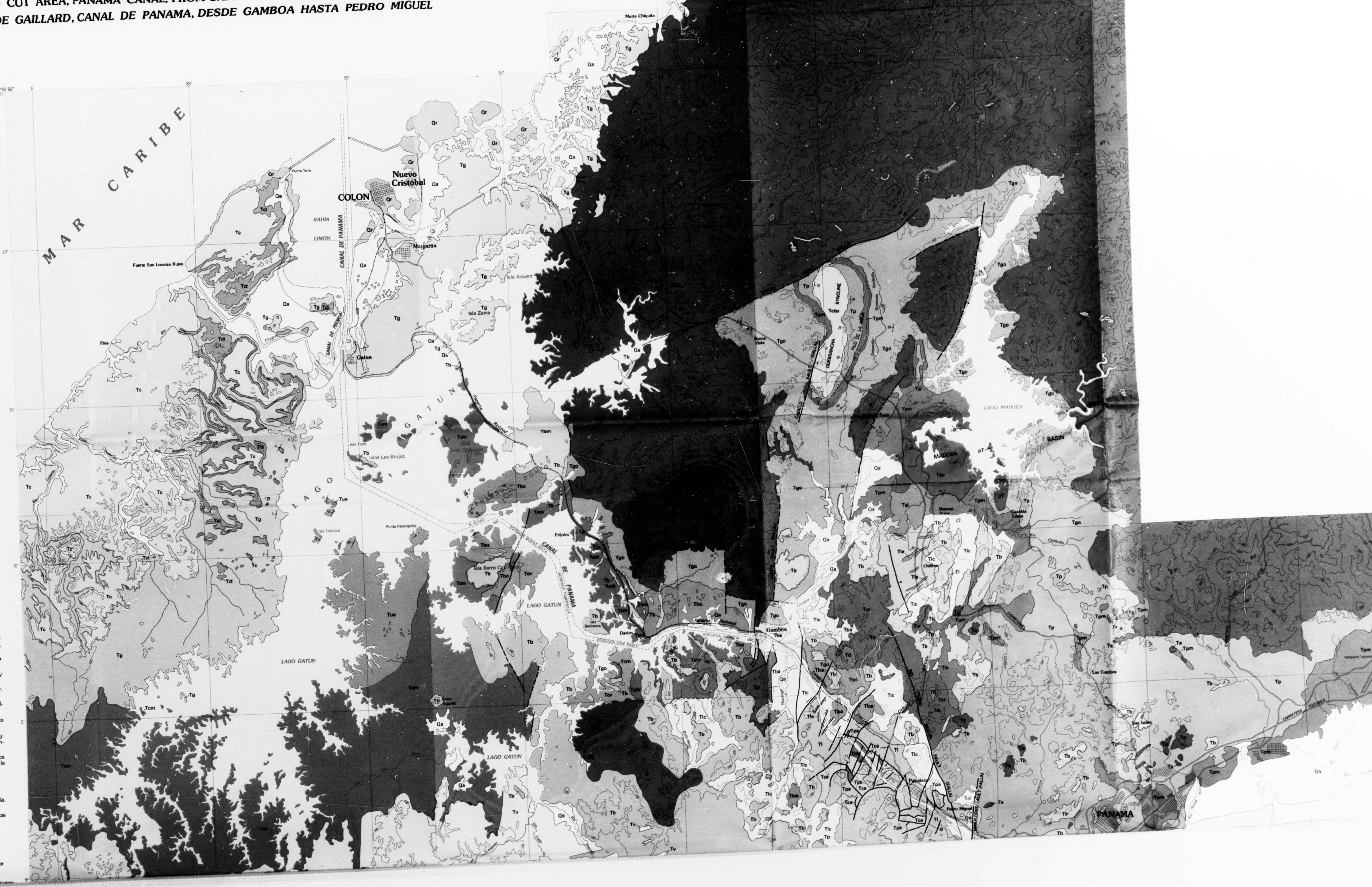
UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

PROFESSIONAL PAPER 306-F
PLATE 1

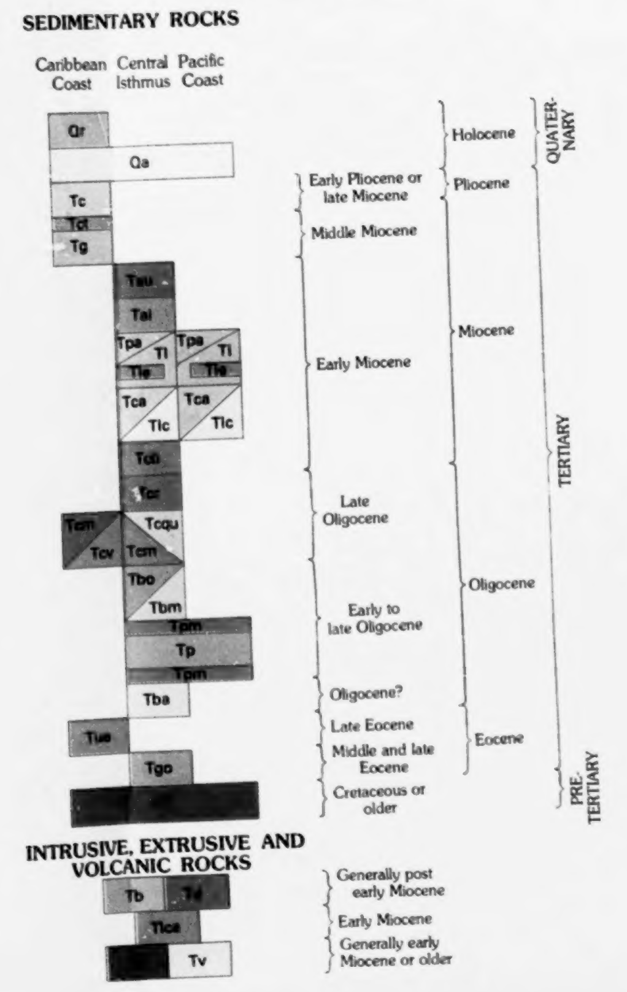

Gamboa
BORDADA OBISPO
BORDADA LAS CASCADAS
BORDADA EMPIRE
BORDADA CULEBRA
BORDADA CUCARACHA
BORDADA PARAISO
Paraiso
Pedro Miguel
SCALE 1:25,000
ESCALA 1:25 000
0 1 2 3 KILOMETERS
0 1 2 MILES
CONTOUR INTERVAL 50 METERS
CURVAS DE NIVEL A INTERVALO DE 50 METROS
VERTICAL DATUM MEAN SEA LEVEL
DATO VERTICAL NIVEL MEDIO DEL MAR
9°00'00"
79°37'30"

GEOLOGIC MAP OF THE GAILLARD CUT AREA, PANAMA CANAL, FROM GAMBOA TO PEDRO MIGUEL

MAPA GEOLOGICO DEL AREA DEL CORTE DE GAILLARD, CANAL DE PANAMA, DESDE GAMBOA HASTA PEDRO MIGUEL


MAR CARIBE
MAR CARIBE
COLON
Nuevo Cristóbal
BAHIA LIMON
CANAL DE PANAMA
Margarita
Gatun
LAGO GATUN
Isla Zorra
Gamboa
Paraiso
LAGO MADDEN
PANAMA
Maria Chiquita
Portobelo

CORRELATION DIAGRAM


SEDIMENTARY ROCKS
Caribbean Coast
Central Isthmus
Pacific Coast
Qr
Qa
Tc
Tct
Tg
Tau
Tal
Tpa
Tl
Tle
Tca
Tlc
Tcu
Tcr
Tcm
Tcv
Tcqu
Tbo
Tbm
Tpm
Tp
Tba
Tue
Tgo
Holocene
Early Pliocene or late Miocene
Middle Miocene
Early Miocene
Late Oligocene
Early to late Oligocene
Oligocene?
Late Eocene
Middle and late Eocene
Cretaceous or older
Pliocene
Miocene
Oligocene
Eocene
QUATERNARY
TERTIARY
PRE-TERTIARY
INTRUSIVE, EXTRUSIVE AND VOLCANIC ROCKS
Tb
Td
Tlca
Tv
Generally post early Miocene
Early Miocene
Generally early Miocene or older

LEGEND FOR GEOLOGIC MAP OF PANAMA AND CANAL ZONE

Undivided Holocene sediments, principally alluvium or fill	Qa	Sedimentos Holocenos, no diferinciados, principalmente aluvión o relleno
Holocene fringing coral reefs	Qr	Arrecifes coralíferos Holocenos
Chagres Sandstone, late Miocene or early Pliocene. Massive, generally fine-grained sandstone	Tc	Arenisca Chagres, Mioceno superior o Plioceno inferior. Arenisca maciza, generalmente de grano-fino
Toro Limestone, basal member of Chagres Sandstone. Coquina	Tct	Caliza Toro, miembro basal de formación arenisca de Chagres, coquina
Gatun Formation, middle Miocene. Sandstone, siltstone, tuff and conglomerate	Tg	Formación Gatún, Mioceno medio. Arenisca, lutita, toba y conglomerado
Alhajuela Formation, upper member, late early Miocene. Tuffaceous sandstone, calcareous sandstone and limestone	Tau	Formación Alhajuela, miembro superior, Mioceno inferiór superior. Arenisca tobacea, arenisca calcarea y caliza
Alhajuela Formation, lower member, late early Miocene. Calcareous sandstone.	Tal	Formación Alhajuela, miembro inferior, Mioceno inferior superior. Arenisca calcarea
La Boca Formation, early Miocene. Mudstone, siltstone, sandstone, tuff and limestone	Tl	Formación La Boca, Mioceno inferior. Esquito arcilloso, lutita, arenisca, toba y caliza
Emperador Limestone, member in lower La Boca. Coraliferous limestone	Tle	Caliza Emperador, miembro en La Boca inferior. Caliza coralífera
Pedro Miguel Formation, early Miocene. Fine-to coarse-grained agglomerate	Tpa	Formación Pedro Miguel, Mioceno inferior. Aglomerado, grano-fino-a grueso
Cucaracha Formation, early Miocene. Bentonic clay shale, carbonaceous clay shale and in lower part, a thin ash flow tuff	Tca	Formación Cucaracha, Mioceno inferior. Arcilla laminada bentonítica, arcilla laminada carbonífera y en la parte inferiór, una capa delgada de ignimbrita
Las Cascadas Formation, early Miocene. Agglomerate and soft, fine-grained tuff	Tlc	Formación Las Cascadas, Mioceno inferior. Aglomerado y toba suave de grano-fino
Culebra Formation, early Miocene. Calcareous sandstone and siltstone	Tcu	Formación Culebra, Mioceno inferiór. Arenisca calcárea y lutita calcárea
Caraba Formation, late Oligocene. Principally a dacite porphyry agglomerate. In type area, conglomerate, fossiliferous calcareous sandstone and limestone	Tcr	Formación Caraba, Oligoceno superior. Principalmente aglomerado de dacítico pórfido. En area typo, conglomerado, arenisca calcárea y caliza, ambas fosilíferas
Caimito Formation, late Oligocene, marine. Tuffaceous sandstone, tuffaceous siltstone, tuff and foraminiferal limestone	Tcm	Formación Caimito, Oligoceno superior, marino. Arenisca tobácea, lutita tobácea, toba y caliza foraminífera
Caimito Formation, volcanic facies, late Oligocene. Agglomerate and tuffaceous graywacke	Tcv	Formación Caimito, facies volcanicas, Oligoceno superior. Aglomerado y grauvaca tobácea
Quebrancha Limestone, member of Caimito Formation, late Oligocene. Foraminiferal limestone and calcareous siltstone	Tcqu	Caliza Quebrancha, miembro de la formación Caimito, Oligoceno superior. Caliza foraminifera y lutita calcárea
Bohio Formation, early to late Oligocene. Conglomerate, principally basaltic and graywacke sandstone	Tbo	Formación Bohío, Oligoceno inferior a superior. Conglomerado principalmente basáltico y arenisca (grauvaca)
Bohio Formation, marine facies, early to late Oligocene. Calcareous sandstone and small-pebble conglomerate	Tbm	Formación Bohío, facies marino, Oligoceno inferior a superior. Arenisca calcárea y conglomerado con guijarros pequeños
Panama Formation, early to late Oligocene. Principally agglomerate, generally andesitic in fine-grained tuff. Includes stream-deposited conglomerate	Tp	Formación Panamá, Oligoceno inferior a superior. Principalmente aglomerado generalmente andesítico en tobas de grano-fino. Incluye conglomerado depositado por corrientes
Panama Formation, marine facies, early to late Oligocene. Tuffaceous sandstone, tuffaceous siltstone, algal and foraminiferal limestone. Sandy siltstone in basal part of formation in Quebrancha syncline	Tpm	Formación Panamá, facies marino, Oligoceno inferior a superior. Arenisca tobácea, lutita tobácea, caliza algácea y foraminífera. Lutita arenosa en la parte basal en el sinclinal Quebrancha
Bas Obispo Formation, Oligocene(?). Agglomerate and hard tuff	Tba	Formación Bas Obispo, Oligoceno(?). Aglomerado y toba dura
Marine rocks, late Eocene. Sandstone and siltstone	Tue	Rocas marinas. Eoceno superior. Arenisca y lutita
Gatuncillo Formation, middle and late Eocene. Mudstone, siltstone, quartz sandstone, algal and foraminiferal limestone	Tgo	Formación Gatuncillo, Eoceno medio a superior. Esquisto arcilloso, lutita, arenisca de cuarzo, caliza algácea y foraminífera
Pre-Tertiary. Altered basaltic and andesitic lavas and tuff. Includes dioritic and dacitic intrusive rocks	■	Anti-Terciario. Lavas y tobas basálticas y andesíticas alteradas. Incluye rocas intrusivas dioríticas y dacíticas
INTRUSIVE, EXTRUSIVE AND VOLCANIC ROCKS		**ROCAS INTRUSIVAS, EXTRUSIVAS Y VOLCANICAS**
Intrusive and extrusive basalt, middle and late Miocene	Tb	Basalto, intrusivo y extrusivo, Mioceno medio y superior
Intrusive dacite and dacite porphyry, Miocene	Td	Dacita, intrusiva y dacita porfido, Mioceno
Andesite, equal in age to Las Cascadas Formation, early Miocene	Tlca	Andesita, la misma edad de formación Las Cascadas, Mioceno inferior
Intrusive and extrusive andesite, Oligocene and early Miocene	■	Andesita, intrusiva y extrusiva, Oligoceno y Mioceno inferior
Volcanic rocks, undifferentiated, generally early Miocene or older	Tv	Rocas volcanicas no diferenciadas, generalmente Mioceno inferior o mas

LEGEND FOR GEOLOGIC MAP OF PANAMA AND CANAL ZONE

Undivided Holocene sediments, principally alluvium or fill	Qa	Sedimentos Holocenos, no diferinciados, principalmente aluvión o relleno
Holocene fringing coral reefs	Qr	Arrecifes coralíferos Holocenos
Chagres Sandstone, late Miocene or early Pliocene. Massive, generally fine-grained sandstone	Tc	Arenisca Chagres, Mioceno superior o Plioceno inferior. Arenisca maciza, generalmente de grano-fino
Toro Limestone, basal member of Chagres Sandstone. Coquina	Tct	Caliza Toro, miembro basal de formación arenisca de Chagres, coquina
Gatun Formation, middle Miocene. Sandstone, siltstone, tuff and conglomerate	Tg	Formacion Gatún, Mioceno medio. Arenisca, lutita, toba y conglomerado
Alhajuela Formation, upper member, late early Miocene. Tuffaceous sandstone, calcareous sandstone and limestone	Tau	Formacion Alhajuela, miembro superior, Mioceno inferior superior. Arenisca tobacea, arenisca calcarea y caliza
Alhajuela Formation, lower member, late early Miocene. Calcareous sandstone.	Tal	Formación Alhajuela, miembro inferior, Mioceno inferior superior. Arenisca calcarea
La Boca Formation, early Miocene. Mudstone, siltstone, sandstone, tuff and limestone	Tl	Formación La Boca, Mioceno inferior. Esquito arcilloso, lutita, arenisca, toba y caliza
Emperador Limestone, member in lower La Boca. Coraliferous limestone	Tle	Caliza Emperador, miembro en La Boca inferior. Caliza coralifera
Pedro Miguel Formation, early Miocene. Fine-to coarse-grained agglomerate	Tpe	Formación Pedro Miguel, Mioceno inferior. Aglomerado, grano-fino-a grueso
Cucaracha Formation, early Miocene. Bentonic clay shale, carbonaceous clay shale and in lower part, a thin ash flow tuff	Tca	Formacion Cucaracha, Mioceno inferior. Arcilla laminada bentonítica, arcilla laminada carbonífera y en la parte inferior, una capa delgada de ignimbrita
Las Cascadas Formation, early Miocene. Agglomerate and soft, fine-grained tuff	Tlc	Formación Las Cascadas, Mioceno inferior. Aglomerado y toba suave de grano-fino
Culebra Formation, early Miocene. Calcareous sandstone and siltstone	Tcb	Formación Culebra, Mioceno inferior. Arenisca calcarea y lutita calcarea
Caraba Formation. late Oligocene. Principally a dacite porphyry agglomerate. In type area, conglomerate, fossiliferous calcareous sandstone and limestone	Tcr	Formación Caraba, Oligoceno superior. Principalmente aglomerado de dacítico pórfido. En area typo, conglomerado, arenisca calcarea y caliza, ambas fosilíferas
Caimito Formation, late Oligocene, marine. Tuffaceous sandstone, tuffaceous siltstone, tuff and foraminiferal limestone	Tcm	Formacion Caimito, Oligoceno superior, marino. Arenisca tobácea, lutita tobácea, toba y caliza foraminífera
Caimito Formation, volcanic facies, late Oligocene. Agglomerate and tuffaceous graywacke	Tcv	Formación Caimito, facies volcanicas, Oligoceno superior. Aglomerado y grauvaca tobácea
Quebrancha Limestone, member of Caimito Formation, late Oligocene. Foraminiferal limestone and calcareous siltstone	Tcqu	Caliza Quebrancha, miembro de la formación Caimito, Oligoceno superior. Caliza foraminífera y lutita calcárea
Bohio Formation, early to late Oligocene. Conglomerate, principally basaltic and graywacke sandstone	Tbo	Formación Bohío, Oligoceno inferior a superior. Conglomerado principalmente basáltico y arenisca (grauvaca)
Bohio Formation, marine facies, early to late Oligocene. Calcareous sandstone and small-pebble conglomerate	Tbm	Formación Bohío, facies marino, Oligoceno inferior a superior. Arenisca calcárea y conglomerado con guijarros pequeños
Panama Formation, early to late Oligocene. Principally agglomerate, generally andesitic in fine-grained tuff. Includes stream-deposited conglomerate	Tp	Formación Panamá, Oligoceno inferior a superior. Principalmente aglomerado generalmente andesítico en tobas de grano-fino. Incluye conglomerado depositado por corrientes
Panama Formation, marine facies, early to late Oligocene. Tuffaceous sandstone, tuffaceous siltstone, algal and foraminiferal limestone. Sandy siltstone in basal part of formation in Quebrancha syncline	Tpm	Formacion Panamá, facies marino, Oligoceno inferior a superior. Arenisca tobácea, lutita tobácea, caliza algácea y foraminífera. Lutita arenosa en la parte basal en el sinclinal Quebrancha
Bas Obispo Formation, Oligocene(?). Agglomerate and hard tuff	Tba	Formacion Bas Obispo, Oligoceno(?). Aglomerado y toba dura
Marine rocks, late Eocene. Sandstone and siltstone	Tue	Rocas marinas. Eoceno superior. Arenisca y lutita
Gatuncillo Formation, middle and late Eocene. Mudstone, siltstone, quartz sandstone, algal and foraminiferal limestone	Tgo	Formacion Gatuncillo, Eoceno medio a superior. Esquisto arcilloso, lutita, arenisca de cuarzo, caliza algacea y foraminífera
Pre-Tertiary. Altered basaltic and andesitic lavas and tuff. Includes dioritic and dacitic intrusive rocks	pT	Anti-Terciario. Lavas y tobas basálticas y andesíticas alteradas. Incluye rocas intrusivas dioríticas y dacíticas

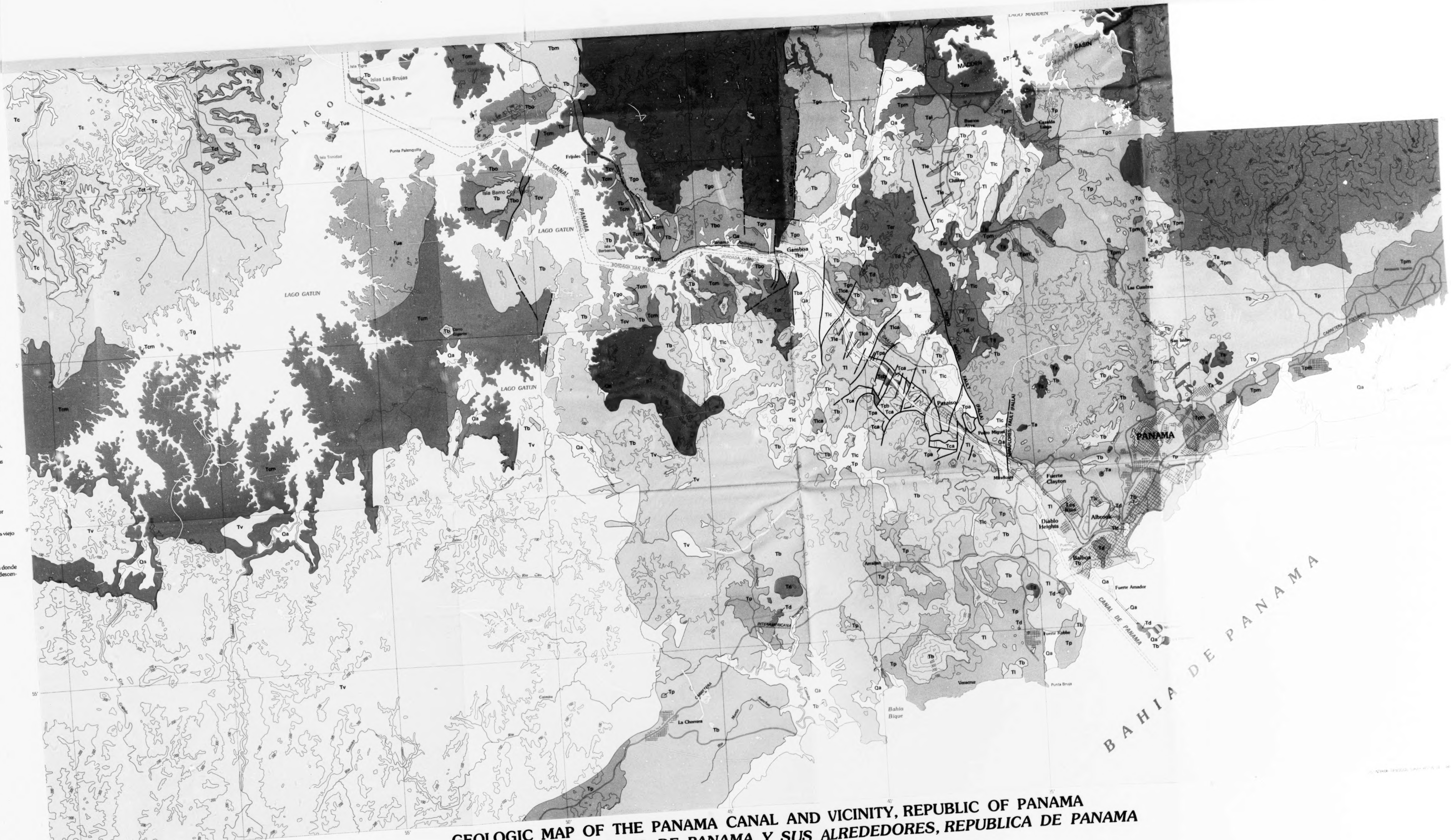
INTRUSIVE, EXTRUSIVE AND VOLCANIC ROCKS

ROCAS INTRUSIVAS, EXTRUSIVAS Y VOLCANICAS

Intrusive and extrusive basalt, middle and late Miocene	Tb	Basalto, intrusivo y extrusivo, Mioceno medio y superior
Intrusive dacite and dacite porphyry, Miocene	Td	Dacita, intrusiva y dacita porfido, Mioceno
Andesite, equal in age to Las Cascadas Formation, early Miocene	Tlca	Andesita, la misma edad de formación Las Cascadas, Mioceno inferior
Intrusive and extrusive andesite, Oligocene and early Miocene		Andesita, intrusiva y extrusiva, Oligoceno y Mioceno inferior
Volcanic rocks, undifferentiated, generally early Miocene or older	Tv	*Rocas volcanicas no diferenciadas, generalmente Mioceno inferior o mas viejo*

Contact		Contacto
Fault—Dashed where approximately located; dotted where concealed. Ball and bar on downthrown side; arrows show relative horizontal movement		Falla—Linea interrumpida donde su localid es approximada; puntcada donde su localidad es cubierta. Bala y barra indica el desplazamiento descendente; flechas indican el movimiento horizontal relativo
Strike and dip of beds		Direccion y buzamiento de los estratos

SCALE 1:100 000
ESCALA 1:100 000
5 0 5 10 KILOMETERS
5 0 5 MILES
CONTOUR INTERVAL 100 METERS
CURVAS DE NIVEL A INTERVALO DE 100 METROS
VERTICAL DATUM: MEAN SEA LEVEL
DATO VERTICAL: NIVEL MEDIO DEL MAR



Base map compiled by E. L. Isenberg from maps at scale 1:25,000 published by the Inter-American Geodetic Survey, Defense Mapping Agency, USA

Mapa básico compilado por E. L. Isenberg de mapas a escala de 1:25,000 publicados por el Servicio Geodésico Interamericano de la Agencia cartográfica de Defensa, de los Estados Unidos de América

GEOLOGIC MAP OF THE PANAMA CANAL AND VICINITY, REPUBLIC OF PANAMA

MAPA GEOLOGICO DEL CANAL DE PANAMA Y SUS ALREDEDORES, REPUBLICA DE PANAMA

Compiled by R. H. and J. L. Stewart with the collaboration of W. P. Woodring

Compilado por R. H. y J. L. Stewart con la colaboracion de W. P. Woodring

1980